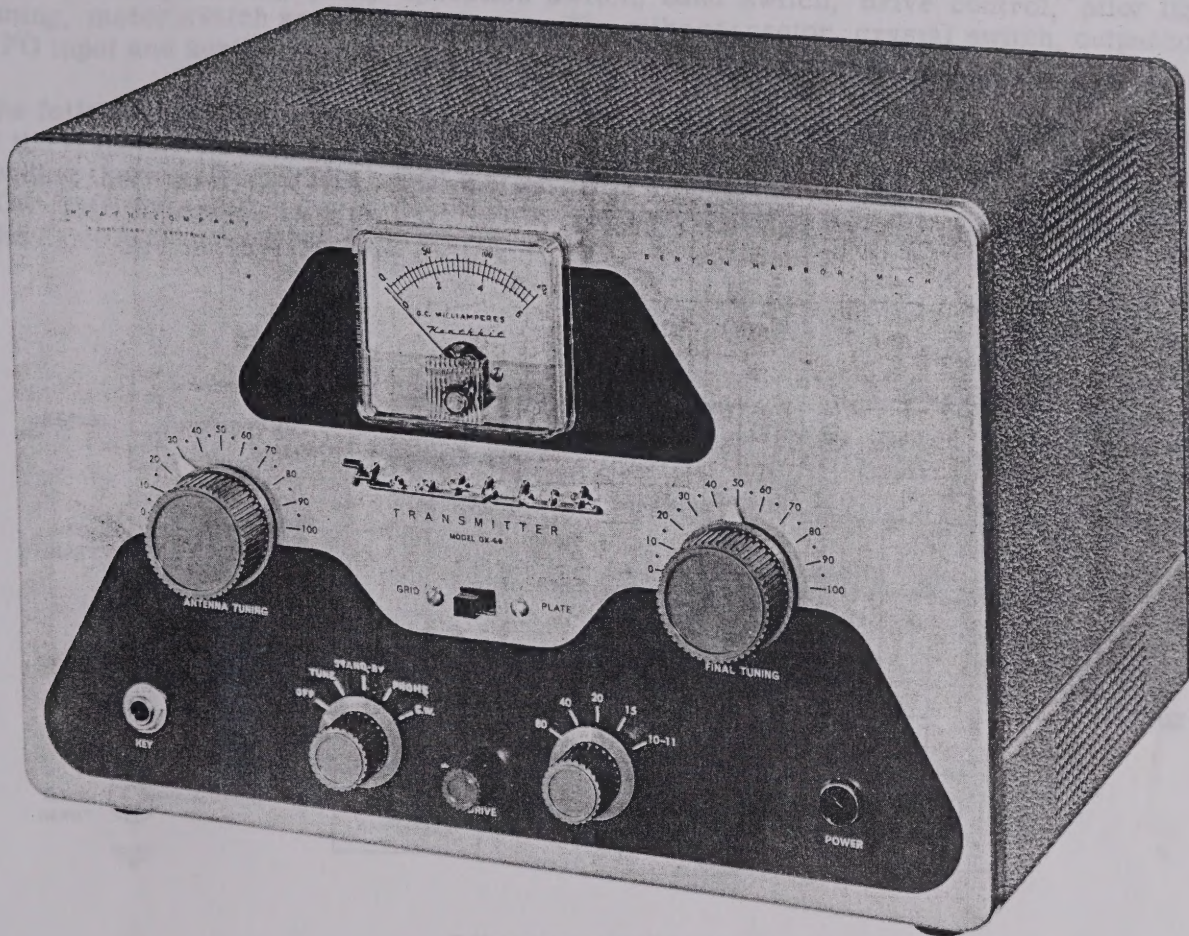


CONSTRUCTION MANUAL NO LONGER AVAILABLE

HEATHKIT AMATEUR TRANSMITTER MODEL DX-40



SPECIFICATIONS

Power Input:	75 watt CW, 60 watt peak controlled carrier phone
Output Impedance:	50-600 Ω
Output Coupling:	Pi network (coaxial)
Operation:	Crystal-VFO, CW, Phone
Band Coverage:	80, 40, 20, 15, 10
Tube Complement:	5U4GB Rectifier 12AX7 Speech Amplifier 6DE7 Carrier Control, Modulator 6CL6 Crystal Oscillator 6CL6 Buffer 6146 Final Amplifier
Power Requirements:	117 volts AC, 60 cycles, 175 watts
Cabinet Size:	13" wide x 8 1/2" high x 9" deep
Net Weight:	21 lbs.
Shipping Weight:	26 lbs.

INTRODUCTION

The Heathkit Transmitter Model DX-40 was designed to permit maximum versatility at a reasonable price. It features up to 75 watts input with three switch-selected crystal positions for the novice operator. It includes controlled carrier phone operation and provision for VFO excitation for the general class ham. It has sufficient output to drive larger transmitters when the station is expanded, yet is small enough for field day operation.

The DX-40 consists of one power supply, three radio frequency stages, and two dual-triode audio stages. Pi network output coupling is used to facilitate antenna matching. The panel controls consists of a key jack, operation switch, band switch, drive control, pilot light, final tuning, meter switch and antenna tuning. The mike connector, crystal switch, output connector, VFO input and auxiliary power socket are located on the rear chassis apron.

The following block diagram and circuit description will give the builder a better understanding of the transmitter. This knowledge is an invaluable aid to construction and as such is well worth reading thoroughly. **LETHAL VOLTAGES ARE PRESENT AT MANY POINTS ABOVE AND BELOW THE CHASSIS. CONSEQUENTLY, GREAT CARE MUST BE EXERCISED WHEN ANY TEST OR ADJUSTMENTS ARE MADE.**

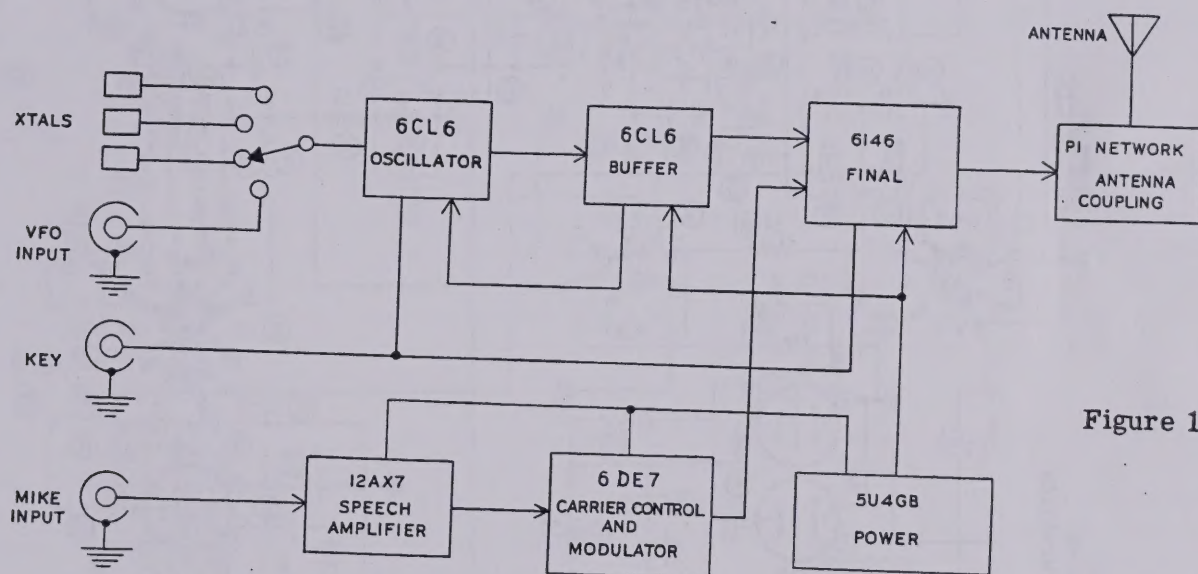


Figure 1

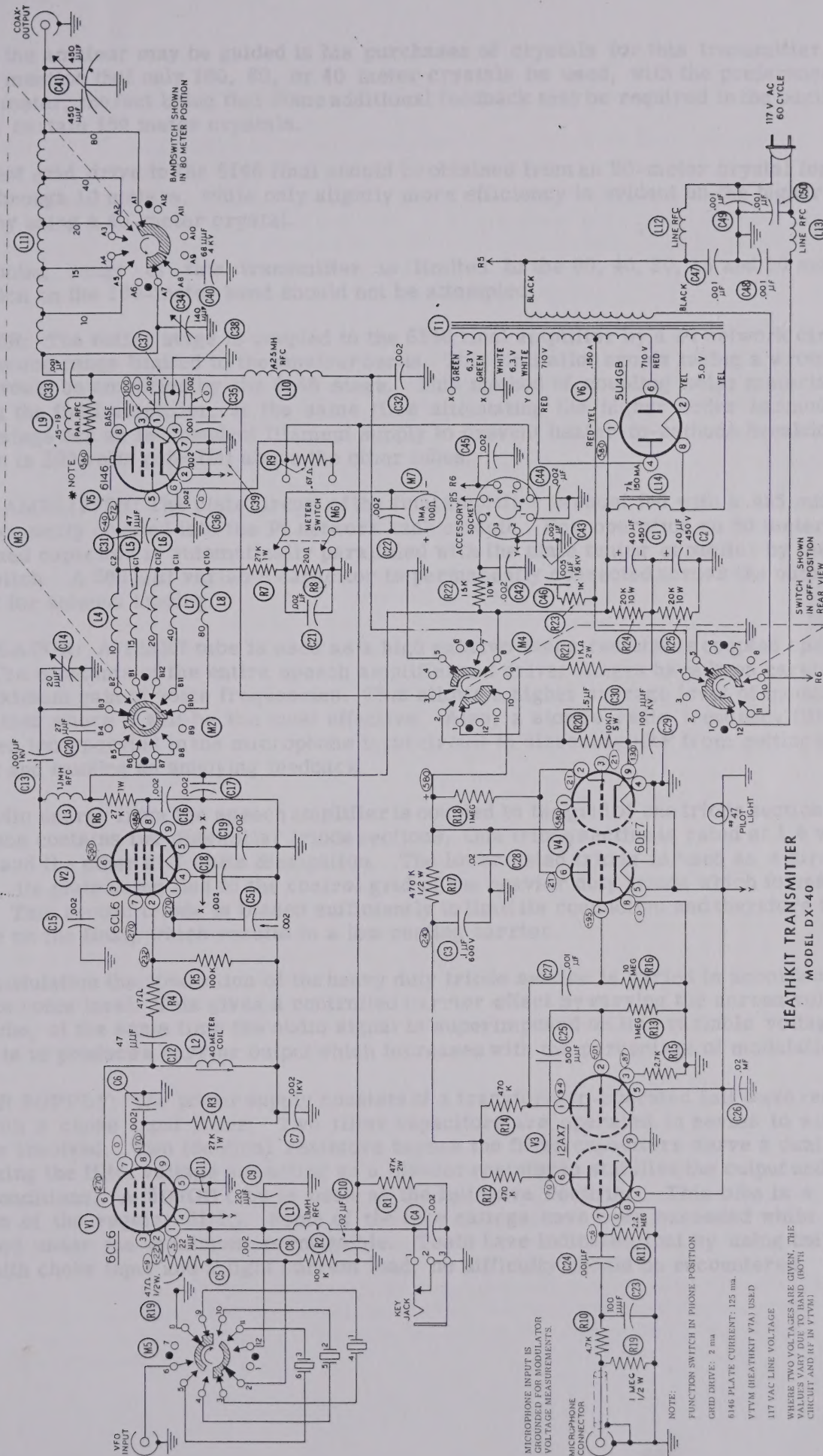
CIRCUIT DESCRIPTION

OSCILLATOR: A 6CL6 tube is operated in a Colpitts circuit to provide efficient harmonic output for use on the high frequency bands. The plate tank circuit consists solely of a slug-tuned coil which is broadly resonant on 40 meters but serves as a radio frequency choke on 80 meters. For operation on 80 through 10 meters the oscillator plate circuit tunes to 40 meters.

Three crystals may be switched into the circuit by means of a double-pole switch which breaks both connections to the crystals to prevent interaction. In the fourth position, the 6CL6 grid is connected to a jack for external VFO control and the cathode RF choke is bypassed to ground.

Plate and screen voltage for the oscillator stage are derived from the buffer stage cathode. The two 6CL6 tubes are operated in series across the 600 volt supply and receive approximately 300 volts each. This eliminates the necessity of power-wasting dropping resistors.

The 6CL6 buffer in most cases, tunes the second, third, or fourth harmonic to obtain the desired frequency. Because the RF level required by the buffer stage is quite low, 80 or 160 meter crystals may be used for output on 80 without the necessity of resonating the oscillator stage plate circuit to these frequencies.



* 6146 PLATE VOLTAGE MEASURED AT PIN 1 OF 5U4GB

So that the amateur may be guided in his purchases of crystals for this transmitter it may be best to mention that only 160, 80, or 40 meter crystals be used, with the preference being 80 and 40 meter, the fact being that some additional feedback may be required in the oscillator circuit for certain 160 meter crystals.

Sufficient grid drive to the 6146 final should be obtained from an 80-meter crystal for operation on 80 through 10 meters, while only slightly more efficiency is evident on the higher frequency bands by using a 40-meter crystal.

The tuning range of this transmitter is limited to the 80, 40, 20, 15 and 10 meter bands. Operation on the 160-meter band should not be attempted.

BUFFER: The buffer stage is coupled to the 6146 final amplifier by a Pi network circuit which has a tuning range limited to the amateur bands. This limitation avoids tuning a wrong harmonic which would be amplified by the 6146 stage. This method of coupling helps materially in stabilizing the final amplifier, at the same time attenuating the higher order harmonics. This buffer stage has an independent filament supply to prevent heater-to-cathode breakdown as this cathode is 300 volts potential above the other tubes.

FINAL AMPLIFIER: The plate circuit of the final amplifier is shunt fed with a .425 mh RF choke and is capacity coupled into the Pi network tank circuit. For operation on 80 meters a 68 $\mu\mu\text{f}$ 4 kv fixed capacitor is automatically paralleled with the plate tuning capacitor by means of the bandswitch. A 900 $\mu\mu\text{f}$ variable capacitor is permanently connected across the output of the Pi circuit for antenna loading.

MODULATOR: A 12AX7 tube is used as a high gain two stage resistance coupled speech amplifier. The constants of the entire speech amplifier and driver stages have been carefully chosen for maximum gain at voice frequencies. This allows a higher average level of modulation to be maintained where it will be the most effective. Also, a simple radio frequency filter network has been incorporated in the microphone input circuit to discourage RF from getting in the audio circuit and causing an annoying feedback.

The audio energy from the speech amplifier is coupled to the grid of one triode section of a 6DE7. This tube contains two dissimilar triode sections. One triode section is rated at 1.5 watts dissipation and the other at 7 watts dissipation. The lower rated triode is used as a direct coupled driver, its plate being tied to the control grid of the heavier duty triode which forms the modulator. This second triode is biased sufficiently to limit its conduction and therefore the screen voltage on the final, which results in a low resting carrier.

With modulation the conduction of the heavy duty triode section is varied in accordance with the average voice level. This gives a controlled carrier effect by varying the screen voltage on the 6146 tube, at the same time the audio signal is superimposed on this variable voltage. The net result is to produce a carrier output which increases with the percentage of modulation applied.

POWER SUPPLY: The power supply consists of a transformer-operated full wave rectifier circuit with a choke input filter. Two filter capacitors are operated in series to withstand the voltage involved. Two identical resistors across the filter capacitors serve a dual purpose of equalizing the filter voltage and acting as a bleeder resistor to stabilize the output under varying load conditions. A 5U4GB tube is used as the full wave rectifier. This tube is a heavy-duty version of the regular 5U4G. Some of the tube ratings have been exceeded while others are operated under the maximum permissible. Tests have indicated that by using the heavy duty tube with choke input and a light current load, no difficulty should be encountered.

NOTE: Due to the action of the polarized electrolytic capacitors the ohmmeter test leads should be interchanged to favor the higher resistance readings.

Again, before applying power, check all solder connections, making sure none have been missed and that all are good electrical connections. Check the coax antenna connector from the center terminal to the outside of the coax for a short. It should check "open". Check the microphone connector in the same manner. It should also check "open".

TUNING INSTRUCTIONS

If any of the following tests cannot be performed or show abnormal indications, turn to the section of the manual entitled Service and Maintenance Hints. Set the transmitter up as follows: crystal switch in any position (no crystals or VFO plugged in); operation switch OFF; drive control in any position; bandswitch 10-11 meter position; antenna tuning "O" position; grid-plate switch in PLATE position; final tuning "O" position.

Plug the line cord into a 117-volt AC receptacle. Nothing should happen, if anything does, pull the line cord immediately. There is trouble in the AC power circuits which must be corrected before proceeding. If operation is normal so far, switch the operation switch to the STANDBY position.

The pilot light and all tubes should light but there should be no meter reading or other indication yet. Switch to PHONE position. With the key plugged in there will now be voltage across the key terminals so use caution. Depress the key momentarily. The meter (switched to PLATE position) should read between 1/2 and full scale. Release the key.

For the following adjustments an 80-meter crystal in the range of 3500 to 3600 or a 40-meter crystal in the range of 7000 to 7200 should be used. A VFO tuned within these limits would also suffice. Install the crystal in any of the three sockets and set the crystal switch for this socket or the VFO position. Set the bandswitch to 10 meters and connect a dummy load such as a 40-watt light bulb from the ground bolt to the center of the coax connector. Switch the meter to read grid current. Set the operation switch to STANDBY and plug the line cord into a power source. Set the loading (antenna tuning) control to "O" (capacitor fully meshed). After about two minutes time for tube warmup, switch to TUNE position, with the meter switched to read grid current, depress the key and adjust the drive control for maximum grid current reading. Release the key.

Locate the 40-meter oscillator coil adjustment on top of the chassis and lubricate it with one drop of light oil. With a radio-TV type alignment tool or a small screwdriver, turn the slug (counter-clockwise) to the end of its travel. Do not try to force it past this point to avoid fracturing the powdered iron core slug.

Close the key and turn the slug (clockwise) until maximum grid current is indicated. Release the key.

NOTE: This indication does not mean that the oscillator plate coil is tuned exactly to the frequency, the fact being that in some cases the oscillator provides more than sufficient drive for the buffer stage, in which case a slight off-tuning of the oscillator coil results in an increased grid current reading to the 6146 final tube.

In general, this tuned coil should be adjusted for the highest reading of grid current near the range of frequencies in which operations are planned. Once adjusted, it can be left alone as long as sufficient grid drive is obtained.

On 10 meters with a 40-meter crystal, a higher reading is obtained with the slug screwed out farther than when an 80-meter crystal is used. In effect, the oscillator is overdriving the buffer with the 40-meter crystal and detuning the oscillator plate circuit reduces the excess drive to the buffer stage.

There is considerable similarity between the screws and nuts of the 3-48 and the 4-40 hardware supplied. Before using these pieces, examine them closely to determine that you have the part called for in the instructions. This is particularly true of the small size 4-40 nuts which resemble 3-48 nuts in physical size. These nuts may even hold on a 3-48 screw, but will feel loose. If any doubt exists, try the nut on a 4-40 screw to check it. There are only three of these and they should be used in mounting the crystal sockets.

In the design of the Heathkit DX-40, no effort was spared to obtain the highest quality components and assemble them in the best possible arrangement. By the same token, the kit builder should exercise a great deal of care during assembly and wiring. Only by putting the best possible workmanship into the kit, can best results be obtained from it. There is also a great deal of personal satisfaction in a neat, professional-looking transmitter, resulting from careful assembly and wiring. A common factor of radio frequency instruments is the critical placement of leads and components. The use of extensive bypassing and shielding in the DX-40 has eliminated a great deal of this. However, the lead dress shown in the pictorials and bottom chassis photograph should be followed carefully.

During the assembly and wiring procedure, a rag or some soft material should be placed over the work bench to prevent marring or scratching the chassis or component finish. Capacitors, resistors and transformers usually have leads longer than necessary to make the indicated connections. In the interest of both efficiency and appearance, the leads should be cut to an appropriate length before the connections are made. In many cases, the specified wire lengths may seem long. These lengths were chosen so the wire could be run close to the chassis and formed for the best appearance.

Marking the letters of the tube sockets and terminal strips on the chassis as they are installed will be a great help during the wiring procedure. The actual tube markings may differ from the type specified in the parts list by an additional suffix (A, B, GT, etc.). This denotes a minor variation which will not affect the operation of the completed instrument.

This manual is supplied to assist you in every way to complete the DX-40 with the least possible chance for error. We suggest that you take a few minutes now and read the entire manual, omitting the step-by-step instructions, before any work is started. This will enable you to proceed with the work much faster when construction is begun. The large fold-in pictorials are handy to attach to the wall above your work space. Their use will greatly simplify the construction of the kit. These diagrams are repeated in smaller form within the manual. We suggest that you retain the manual in your files for future reference both in the use of the DX-40 and for its maintenance. During the initial testing of the transmitter, it will be out of its cabinet. **REMEMBER THAT VOLTAGES DANGEROUS TO LIFE ARE PRESENT AT PRACTICALLY ALL POINTS ON THE CHASSIS.**

NOTE: Sometimes the builder may find a place where it is difficult to hold a nut for assembly. Using long-nosed pliers, press a piece of solder across one side of the nut until the solder is forced part way into the threads. This will hold the nut and furnish a narrow handle useful for inserting the nut into tight places.

In order to expedite delivery to you, we are occasionally forced to make minor substitutions of parts. Such substitutions are carefully checked before they are approved and the parts supplied will work satisfactorily. By checking the parts list for resistors, for example, you may find that a 2 K Ω resistor has been supplied in place of a 2.2 K Ω as shown in the parts list. These changes are self-evident and are mentioned here only to prevent confusion in checking the contents of your kit. We strongly urge that you follow the wiring and parts layout shown in the manual. The position of wires and parts is extremely critical in a stable transmitter and changes may seriously affect the characteristics of the circuit. Resistors and condensers generally have a tolerance rating of $\pm 10\%$ unless otherwise stated in the parts list. Therefore, a 100 K Ω resistor may test anywhere from 90 K Ω to 110 K Ω . The letter K is commonly used to designate a multiplier of 1000.

Upon obtaining a reading at, or near 3 milliamperes grid current to the final amplifier, switch the meter to read plate current. The operation switch is switched to PHONE position and the final tuning control is tuned to the lowest reading of plate current. This "dip" should occur near #90 on the dial with the bandswitch on 10 meters.

NOTE: These tests were made with a 3500 kc and 7000 kc crystal. The "off-tuned" plate current generally does not exceed 75 milliamperes due to the low screen voltage on the 6146 in the PHONE position without modulation. Once tuned to minimum current in the PHONE position, switch to CW operation. This will show a much higher average plate current, with more pronounced "dips".

To load the antenna or dummy load, always start with the antenna tuning (loading) control closed at "O" position. The final tuning is always tuned to resonance, or minimum plate current. When the loading control is moved, it detunes the output circuit and this has to be compensated for by redipping the final tuning control to resonance. Keeping this in mind, gradually open the antenna tuning to indicate #20 on the dial. Now return to the final tuning control and redip it to minimum current. Increase the loading to approximately 40 on the dial. Redip the final to minimum. Increase the loading still farther and redip the final until the "dip" is at, or near, the recommended "loaded" current which is 125 milliamperes in the CW position.

This successive loading and redipping is recommended for tuning of the pi network output circuit of this transmitter except when using an antenna tuner or coupler, in which case the loading capacitor is left closed at or near the "O" position to provide a low impedance.

It would be more convenient to make the operation of "loading" two handed. Bringing up the loading with the left hand and dipping the final with the right hand in succession until the required plate current is reached. With a little practice "loading" will be no problem. When loaded to the full CW rating, switch to PHONE position and modulate. With sufficient modulation the plate current should kick-up near 125 milliamperes on peaks. If a light bulb is being used as a dummy load it should increase in brilliance in accordance with the voice level. A field strength meter or the "S" meter on the station receiver will also show a definite increase in carrier level.

NOTE: This particular modulation system requires quite heavy antenna loading. Loading to the CW rating and then switching to the PHONE position is customary procedure. It has been noted that with a constant audio tone of sufficient amplitude the RF output can be adjusted to maximum with greater ease. Depending on the voice of the operator, the gain of the microphone, and the amount of antenna loading, an ideal position between the operator and the microphone should be chosen and maintained for proper modulation. Extremely close talking with a high gain microphone should be avoided to prevent clipping of modulation peaks.

In most cases the RF gain control of the receiver has to be reduced and/or the antenna removed or the antenna terminal grounded to the receiver chassis to prevent pinning the "S" meter. With the gain reduced on the receiver to prevent overloading the AVC or causing audio feedback, the speech should sound clear and distinct.

NOTE: There are times when quite heavy loading is obtained with the (antenna tuning) loading capacitor completely closed at "O" position. This will occur especially at the low frequency end of the 80-meter band when working into a low impedance 50 Ω line. When this occurs, additional capacity will be required in parallel with the 2-gang loading capacitor. See Service and Maintenance Hints.

INSTALLATION AND OPERATION

NOTE: It should be noted that an Amateur Radio Operator and Station License is required to place this transmitter on the air. Information regarding licensing and amateur frequency allocations may be had from publications of the Federal Communications Commission or the American Radio Relay League. This transmitter can be used for novice operation only if the following two requirements are met: (a) CW operation only. (b) Crystal control only, on assigned novice frequencies.

GROUNDING: The importance of a good ground that presents low impedance at all frequencies cannot be emphasized too strongly. What may be a perfectly satisfactory ground at 80 meters could place the transmitter considerably above ground at the higher RF frequencies. As an example, the length of the ground wire is sometimes critical. An 8 foot wire from the transmitter to ground would be a direct short at 80 meters but becomes one-quarter wave length at 10 meters and therefore places the chassis at a high RF potential. Some hints that will be of assistance in obtaining a good ground are:

1. Connection for the ground should be made to cold water or well pipes and/or multiple pipes or rods driven approximately eight or more feet into moist earth. A salt solution poured around the ground rods will further increase the conductivity to ground. A more elaborate installation might include a system of wires approximately one-quarter wave length long laid a few inches under the surface of the earth in a grid or radial pattern. The use of one or all of these grounding systems may be combined to form a good ground reference.
2. The electrical connection to the ground point should consist of a short heavy conductor (#12 wire or heavier, or copper braid). If a short ground wire is difficult to obtain because of transmitter location, several leads of random length may be used. The use of random leads lessens the possibility that all leads should become one-quarter wave length at the frequency of operation. If the transmitter becomes hot with RF at one particular frequency, the addition of a ground wire cut to one-half wave length at this frequency may clear up the difficulty.

Some of the symptoms of inadequate grounding are manifested in the form of:

1. Inability to load the antenna properly.
2. High RF potentials on the chassis or case of the transmitter as well as the microphone and cable.
3. Undue voltage strain on output circuit components.
4. Final plate current reading affected by touching the panel or case.
5. Television or broadcast interference.

LOCATION: The transmitter should be located where free circulation of air is possible and objects should not be placed on the case as this might restrict the circulation of air. Good ventilation is essential to insure maximum component life. The considerations mentioned with regard to grounding will also affect the selection of a good location, as will the point of entry of the antenna feed line.

OPERATION: The tuning procedure outlined previously will also apply when loading an actual antenna. Some special cases involving particular antenna types will require special consideration and will be covered under antennas.

ACCESSORY SOCKET

The octal accessory socket on the rear of the chassis was provided to furnish power for an external VFO such as the Heathkit VF-1. Filament power is obtained from pins 1 and 2 with 1 being ground for operation of an external unit having one side of the filament at ground potential. Pin 4 supplies B+ voltage through a 20 K Ω 10 watt resistor. This provides approximately 250 volts at 20 milliamperes. Pin 8 is connected to the cathode keying circuit and allows an external VFO to be keyed along with the DX-40. Pin 1 is grounded for the filament and the shield cable between the transmitter and the VFO. See Figure 21.

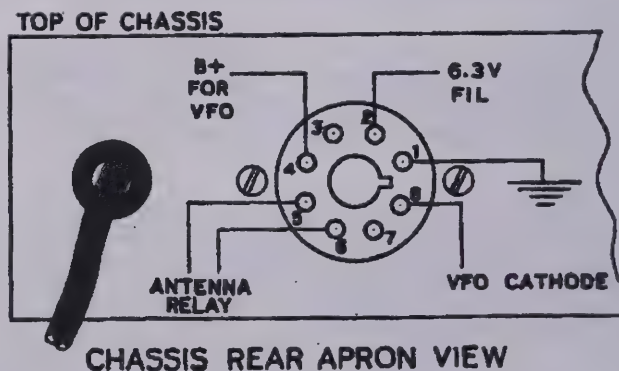


Figure 21

NOTE: Connection points are provided on the Accessory socket for the operation of an antenna relay, to take advantage of the improved receiver performance realized when using the transmitting antenna on the receiver.

Switching the operation switch to either the PHONE or CW position will provide the full line voltage at socket connections #5 and #6. CAUTION: This switch breaks only one side of the line, consequently socket connection #5 is always "alive" with the line voltage. We urge that due safety precautions be observed when connections are made to the accessory socket and relay circuit.

SERVICE AND MAINTENANCE HINTS

WARNING: Voltages dangerous to life are present at practically all points on the chassis. The Heath Company will not be responsible for injuries which could occur while making tests. Do not attempt to make voltage checks or service the transmitter without taking standard precautions and using the proper equipment. If in doubt, secure the assistance of a competent technician.

IMPORTANT: Read list of errors that could possibly damage your transmitter.

General Service

Analyzing and Isolating Difficulties

Power Supply

Oscillator Stage

Buffer Stage

Final Amplifier Stage

Speech Amplifier and Modulator Stages

Grid Drive -- See Oscillator and Buffer Sections

Plate Current -- See Final Amplifier Section and Antenna Considerations.

Meter Circuit

Antenna Considerations and TVI.

Listed below are several of the common mistakes that can permanently damage components in your transmitter. Oftentimes while hunting for a minor difficulty in a particular section of the transmitter with the power on, components in another section may be seriously damaged. For example, a high current will be flowing in the final amplifier tube if the final tuning control is not in resonance while observing grid drive readings with the operation switch in the CW position. Switch to the TUNE position.

1. Don't make voltage checks without proper safety precautions. Voltage checks should be done without any distraction. Children should not be allowed near the equipment. Electric shock can be fatal.
2. Don't turn the transmitter to the CW or PHONE position unless you have first obtained a reasonable grid drive reading on the TUNE position.
3. Don't operate the transmitter without proper crystals installed, or the VFO tuned to the proper frequency. Be sure the CRYSTAL-VFO switch is turned to the proper position.
4. Don't leave the transmitter in operation over 5 minutes, even when testing. The duty cycle of the power transformer is 5 minutes on and 10 minutes off. This, of course, refers to continuous operation and does not apply to CW or PHONE operation. PHONE or CW operation under normal operating conditions will not approach the maximum limit.
5. Don't cover the ventilation holes provided in the cabinet.
6. Don't test the oscillator, buffer or modulator stages with the final amplifier on PHONE or CW position if it is not dipped to resonance as indicated by minimum plate current.

Don't try to read grid current to the final amplifier:

- a. When the key circuit is open.
- b. When the meter switch is in the plate position.
- c. With an improper crystal (the drive control tunes a limited range).
- d. With the CRYSTAL-VFO switch in the wrong position.

GENERAL SERVICE

SOLDERING: Cold and loose solder connections are a common source of trouble in assembling any piece of electronic equipment. Sometimes apparently good solder connections will have an insulating coating of rosin between the wire, the terminal and the solder. This type of defective soldering is very difficult to locate in the process of trouble-shooting, and the builder will do well to see that each wire in a connection point is firmly embedded in the solder. Many times when more than one wire is connected to a terminal or lug the lower wire will not receive sufficient heat or solder even though the connection looks satisfactory. Trouble can also be caused by being too generous with solder and heat, with a short resulting from solder running down the lug and touching the chassis or other components. Use extreme care when soldering to switch contact points, to avoid solder running too far and spoiling the spring tension of the contacts.

With miniature tube sockets there is a possibility of shorts between adjacent socket terminals due to the close spacing. This should be checked and if any doubt exists, the terminals should be pried apart until obvious spacing can be seen between them.

In general, do not rely on the solder itself to form the electrical connection. A firm metal to metal contact should be made before flowing the solder over it.

COMPONENTS: Any part that physically looks defective should be tested with the proper instrument.

TUBES: Tubes can be checked on a tube checker but the best method is by substitution. An extra set of tubes should be on hand for testing and to replace normal tube failures.

WIRING: Mistakes in wiring are the most common cause of difficulty. Consequently, the first step is to recheck all wiring against the pictorials and schematic diagrams. Often having a friend check the wiring will locate an error consistently overlooked.

Follow the construction manual and pictorials so that each lead is placed in its proper position. Make leads as short as possible, except where leads are measured or specifically routed around the edge of the chassis. This is to prevent adverse effects such as spurious RF oscillations and audio feedback.

CAUSE AND EFFECT: Be sure to reread the circuit description on page 3 so that "cause and effect" reasoning may be employed as the search for trouble progresses. If some difficulty still persists after the steps outlined have been completed, attempt to localize the trouble to a particular stage in the transmitter circuit. Use the tuning procedure as a basis for localization and refer to the block diagram and schematic to visualize circuit relationships. The panel meter and station receiver are valuable tools to use in locating trouble.

TRACING PROCEDURE: For the following tracing procedures, use the schematic diagram for reference.

If any activity is noted when the line cord is plugged in and the operation switch is in the OFF position the AC circuit should be traced. One side of the line cord is connected through a line choke to one side of the primary of the power transformer. The other side of the line cord is connected through a line choke to the blue cable wire which connects to terminal 11 of the operation switch; the black cable wire returns from switch terminal 12, to the other primary side of the transformer. Contacts 11 and 12, of the switch thus control line power to the transformer. Also check the four .001 μ f 1400 volt disc ceramic capacitors connected across the line for shorts.

If the tubes and pilot light do not light up when the operation switch is set to STANDBY position, again check the AC circuit with the line cord unplugged to determine why the transformer is not receiving power. If the tubes do light up with the power on and the meter reads in PLATE position, or some other indication of high voltage being applied is apparent, check the following. Unplug the line cord, then with an ohmmeter, check from #5 on KK to ground. It should read

an open circuit. This is the power transformer center tap. The white cable wire at KK5 should connect to terminal 4 of the operating switch and through terminal 5 to ground but should not be grounded in the STANDBY position. Check this wiring to be sure it is correct. CAUTION: The following tests are made with power on; use extreme care. With a low impedance load (near 52 ohms) connected, the operation switch in the PHONE position, the meter switch in PLATE position, depress the key momentarily. It should read about 1/2 scale, when not tuned to resonance. If the meter shows little or no indication, check the screen voltage at pin 3 of the 6146 tube with a (VOM) Volt-Ohm-Milliammeter using a DC range of at least 150 volts. The screen should read about 100 volts. If much less than this, trace back through contact 3 of the operation switch, through contact 2 to pin 9 of the 6DE7 tube; all should read near 100 volts. Switch the meter to a higher range, 1500 volts, and check pin 1 of the 6DE7. This should read about 580 volts. If the voltages are missing or very far from normal, using the voltmeter on the 1500 volt scale with the schematic diagram, trace the voltage back to its source at the rectifier pin 1. No voltage at E1 indicates an open power transformer primary, open power transformer center tap outlined in the steps above, defective 5U4GB rectifier tube or a short circuit. The latter would probably have made itself known by now.

Lack of grid drive may be traced back to the oscillator. Turn to the TUNE position, make sure the key circuit is closed, and listen with a receiver for the oscillator. Try different crystals. If no signal is heard, check the plate voltage of the oscillator at pin 6 and screen voltage at pin 8. There should be about 250 volts on the plate and about 150 on the screen in the TUNE position.

If low grid drive is experienced on either the 15-meter or the 20-meter band positions, disconnect the 80-meter (black dot) coil from the band switch, turn it end for end, reform the leads, and solder back in place.

As the two 6CL6 tubes are in series, no voltages on the oscillator may be due to an open circuit or defective 6CL6 in the buffer stage. Consequently, both stages must be operating properly to obtain grid drive. The plate voltage of the buffer stage will be about 580 volts to ground and its cathode should be about 250 volts to ground (in the TUNE position). If the voltages differ greatly, remove the power and completely check the circuit.

In certain rare cases, keying is completely normal in the TUNE position but erratic keying, or no keying at all, occurs in the CW position. This condition is generally corrected by carefully removing exactly 23 turns of wire from the 40-meter slug tuned coil, Part #40-104. Begin at the red dot terminal, which is the outside of the winding. This changes this coil to a 20-meter coil. Use the same procedure as prescribed on page 31, tuning the slug for the first peak in grid current. Sufficient drive should still be obtained on all bands using proper crystals or VFO.

FINAL AMPLIFIER STAGE: The 6146 final tube can be damaged in a few seconds if the final is not tuned to resonance. If you wish to test other stages with the plate current on, switch to the TUNE position. This will enable you to operate the transmitter up to the final amplifier, including the indication of grid current on the panel meter without any RF output. The TUNE position removes the plate and screen voltage from the 6146 and grounds the screen grid, however, use caution as the high voltage is still present in other sections of the transmitter. Failure to obtain a dip in plate current when tuning the final amplifier may be due to a lack of grid drive, incorrectly wired final tank coil, loading capacitor advanced too far (insufficient capacity), shorted coax line, the crystal switch in the wrong position, or with an improper crystal or one out of the tuning range of the buffer stage.

A low impedance antenna system on the 80-meter band will also give the same effect and may even result in the meter being "pinned" at the full scale reading until sufficient capacity has been added in parallel to the 2-gang output loading capacitor. See Final Amplifier section.

NOTE: When using the DX-40 on CW with the VF-1, the VF-1 operation switch should be placed in the STANDBY position, and the key plugged into the DX-40. For best results with either crystal or VFO, the grid drive should be adjusted as near as possible to 3 milliamperes. In some cases and on certain bands, slightly more than the indicated 3 milliamperes will result in added efficiency.

ANALYZING AND ISOLATION

The transmitter can be divided into stages. Each stage can then be isolated and worked on individually. In the next section, simple steps will be outlined to test each stage. A Vacuum Tube Voltmeter or Multimeter is necessary to check voltages and resistance. Voltages listed were made with a Heathkit Multi-purpose VTVM (Vacuum Tube Voltmeter). The line voltage was 115 volts AC. The transmitter was set up for crystal controlled 80-meter PHONE operation (key circuit closed) for most checks.

Voltages listed do not necessarily indicate those in your transmitter. Line voltage variation, component tolerance and the presence of RF will cause variations. They should only serve as a basis of comparison. AC filament voltage may read high due to the presence of RF which affects the readings on vacuum tube type voltmeters. A more conclusive check in this case may be obtained with a meter such as the Heathkit Volt-Ohm-Milliammeter.

POWER SUPPLY

TUBE E 5U4GB RECTIFIER

1. Check the rectifier tube E by substitution. Be sure the socket is wired to the correct pin connections.
2. REMOVE THE LINE CORD FROM THE POWER SOURCE. Make certain that the filter capacitors are discharged. Test the filter capacitors and high voltage circuit by measuring the resistance between pin #1 of the 5U4GB rectifier tube E and the chassis. It should read between 40 K Ω and 50 K Ω in all positions of the operation switch. A much lower resistance reading may indicate a short circuit in the B+ circuit, a leaky or shorted filter capacitor, or the ohmmeter leads not polarized properly. The meter polarity should favor the higher readings.
3. Check the operation switch for open contacts, or solder that has run into the contacts.
4. Test the transformer by removing the rectifier tube E and measuring the AC voltages. The voltage between the yellow leads should read approximately 5 volts. The voltage between each red lead and the center tap should be 700 to 800 volts. The center tap is the yellow and red lead. Both filament windings should read approximately 6.3 volts AC. The green leads are filament winding #1 and the white leads are filament winding #2.
5. Inspect the filter capacitors and see that they are polarized properly. If not, they should be replaced if current has been allowed to flow through them for any length of time.

OSCILLATOR STAGE

TUBE D 6CL6 OSCILLATOR:

1. Test the 6CL6 tube D by substitution.
2. Check the crystal switch. Make sure the switch is turned to the proper crystal or VFO position.
3. Test the crystal you are using by substituting other crystals of proper frequency.
4. Test the 1.1 mh RF choke in the cathode circuit for an "open" winding (POWER OFF).
5. Check the 40-meter plate coil for an "open" winding (POWER OFF).
6. Filament voltage should check near 6.3 V AC from pin #4 on socket D to chassis.
7. Plate voltage should read approximately 225 to 275 volts, depending on the adjustment of the drive control. This reading is taken from #1 on terminal strip FF to chassis, in the TUNE position.
8. Screen voltage should read approximately 135 to 165 volts depending on the adjustment of the drive control. This reading is taken from Pin #8 on the 6CL6 socket D to the chassis.

BUFFER STAGE

TUBE C 6CL6 BUFFER:

1. Test the 6CL6 tube C by substitution.
2. DISCONNECT THE LINE CORD. Inspect the rotary switch contacts. Be sure there is no solder on the contacts and that each is making a good electrical connection with the rotor.

3. If little or no grid drive is available, there is the possibility that the small buffer coils have been interchanged. A rough check can be made by noting the size of the wire and apparent number of turns. Fine wire and more turns are used on the low frequency coils, with progressively larger wire and lesser turns as 10 meters is approached. Check each coil for a broken winding which would check "open" on an ohmmeter. Also, be sure the coil leads do not short to each other or to the switch frame.
4. WITH ALL POWER REMOVED, test the 1.1 mh RF choke which is connected in the plate circuit for an open winding.
5. With the line cord plugged in, high voltage will be indicated on all pins except 4 and 5 (if measurements are taken from the chassis). This is due to the buffer stage being operated in series with the oscillator stage. Voltage readings on the buffer stage should be taken from the tube cathode which is tied to lug #1 on terminal strip FF. CAUTION: Both meter leads will therefore be "alive". Plate voltage read from lug #1 on terminal strip GG should be approximately 350 to 400 volts (TUNE position), depending on the adjustment of the drive control. Screen voltage should be about 230 volts, also depending on the adjustment of the drive control. Approximately 6.3 volts AC should be indicated between filament pins 4 and 5 on socket D.

FINAL AMPLIFIER

TUBE F 6146

1. Test the 6146 tube G by substitution.
2. Grid drive should be approximately 3 ma. for proper operation.
3. WITH THE LINE CORD DISCONNECTED, check the .425 mh RF choke in the final plate circuit with an ohmmeter.
4. Tighten the nuts on the feedthrough insulators (top and bottom).
5. Inspect the antenna tuning condenser and the final amplifier condenser for shorts, such as solder drips from capacitor terminals shorting to the chassis.
6. Check the 68 μf capacitor between the bandswitch terminal A8 and the grounded lug on the terminal strip. A swollen capacitor will indicate that the component has been damaged by excessive RF current due to trying to load an improper antenna impedance. The swelling of the capacitor will have decreased in its capacity and it will require replacement. This capacitor is only used in the circuit on the 80-meter band.
7. Inspect the connections of the final tank coil to the bandswitch. Make sure each is connected to the proper terminal on the switch.

GRID DRIVE to the final amplifier stage is essential to supply safe operating bias to the 6146. The final amplifier should not be on for more than a few seconds if no grid drive is indicated on the panel meter.

THE DRIVE CONTROL tunes only the upper and lower extremes of the band, no (outside) harmonics.

KEYING is accomplished by grounding the cathode of the Final Amplifier and the Oscillator stage. Poor solder connections in this circuit can cause erratic keying.

DIPPING the final is accomplished by tuning the stage to resonance or to minimum plate current indication. The antenna tuning or loading capacitor should be closed at "O" position before beginning to load an antenna. Dip the final to read minimum plate current, open the loading capacitor a little at a time, successively redipping the final until the final "dip" is at the recommended current value. If the dip is too low on the plate meter and it is impossible to load it with the

Antenna Tuning Condenser, the antenna impedance is not proper and should be checked. This is also true if it will not dip at all. The easiest test for this condition is to substitute a dummy load, (a 115 volt, 60-watt bulb) for the antenna.

NOTE: Feeding a very low impedance antenna, especially at the low frequency end of the 80-meter band may require additional capacity, such as a .001 μ f (large size mica) connected across the coax output connector to allow a proper "dip" in plate current. This may be done with a coax "T" connector if required. CAUTION: Remove this capacitor before attempting operation on any other band as it will make it impossible to "load" the antenna.

CREEPING PLATE CURRENT will usually indicate a "soft" 6146 final amplifier tube. Loss of grid drive usually accompanies this condition. This is usually caused by consistent operation of the 6146 tube in an overloaded condition. Plate voltage reading will be the total B+ voltage which can be read at Pin #1 on the 5U4GB rectifier socket E and should be near 600 volts. Once again, use caution in testing high voltages. The screen voltage (with no modulation) should be about 100 volts.

SPEECH AMPLIFIER AND MODULATOR STAGES

TUBE A -- 12AX7 Dual Triode

TUBE B -- 6DE7 Dual Dissimilar Triode

1. Test the 12AX7 tube A, and the 6DE7 tube B, by substitution.
2. With the line cord disconnected, test the resistance between the ungrounded end of the .1 μ f paper capacitor (lug #1 on terminal strip BB) and the chassis. It should read approximately 500 K Ω on the OFF and PHONE positions. The other switch positions should show no readings.
3. Inspect all pin connections on the tube sockets for poor solder connections.
4. Recheck the step-by-step wiring and be sure that components and leads are connected to the correct numbered pin connections on the sockets.
5. With a crystal plugged in, the power on and the transmitter tuned for CW conditions, switch to PHONE position. Measure the voltage from lug #1 on terminal strip BB to the chassis. It should read approximately 230 volts, as read on a Heathkit VTVM. The plate voltage on the first triode section of the 12AX7, read from pin #6 to the chassis with the VTVM, should be about 70 volts on the 150 volt scale, and the grid voltage near -.6 volts on the 1.5 volt scale, read from pin #7 to the chassis. The second triode plate, from pin #1 to chassis, should read about 90 volts. The first triode cathode is grounded. Voltage reading on the 12AX7 second triode cathode should be about .9 volts, measured across the 2.7 K Ω resistor, from pin #3 to the chassis.
6. Plate voltage on the 7 watt triode section of the 6DE7 should be approximately 580 volts. This is read from pin #1 of the 6DE7 to the chassis. This same voltage read from plate to cathode (pins #1 to #9) is about 460 volts. The plate voltage of the 1.5 watt driver triode is near 20 volts (with no modulation), read on the 50 volt scale of the VTVM, from pin #6 to chassis. The first triode cathode is grounded. Screen voltage for the 6146 final amplifier is obtained (through the 10 K Ω resistor) from the heavy duty triode section cathode, which is pin #9. The voltage at pin #9 to chassis is approximately 115 volts and at the 6146 screen grid pin #3 is near 100 volts with no modulation. The grid voltage read from pin #7 to chassis, with the VTVM, should be near -.9 volts.

METER CIRCUIT: A 100 Ω one milliamperere D'Arsonval movement meter is switched to read plate or grid current to the 6146 final amplifier tube. To avoid extreme excursions of the meter pointer while operation on CW, it may be advisable to leave it switched to the lower reading grid position.

The meter shield can serves to mount the meter as well as shielding any RF radiation through the meter hole which could cause TVI.

PRELIMINARY OPERATION CHECKS

Before applying power to the transmitter, examine your wiring very carefully for possible shorts, such as tube pins touching, resistor or capacitor leads contacting each other, or shorting to the tube socket center shield or to the chassis, coil leads shorting to each other or to the bandswitch frame. Also be sure no wire clippings or solder drops are loose in the chassis. Turn it upside down and give it a good shake.

If there are any short circuits, serious damage may result to the tubes and components when power is applied. As an additional check, **WITH THE LINE CORD DISCONNECTED FROM THE POWER SOURCE**, connect an ohmmeter from pin #1 on socket E to ground. It should read approximately $40\text{ K}\Omega$ in all positions of the operations switch. A very abnormal reading at this point in the circuit should be completely investigated before applying power.

THE ANTENNA

NOTE: How important a part the antenna plays in attaining the final result required of a transmitter cannot be stressed too strongly. Any additional effort spent to obtain an "ideal" antenna will more than pay for itself in making possible many satisfactory "over the air" contacts.

The pi network output circuit of the Model DX-40 will match pure resistive loads from approximately 50 to 1000 Ω , and will eliminate the need for an antenna coupler when used with nominal impedance feed lines. The transmitter will match antennas and unbalanced lines within these limits provided such antennas or lines are nonreactive. Reactive antennas or lines present a somewhat different problem since the reactance takes the form of impedance which may raise or lower the antenna impedance beyond the matching range of the transmitter output circuit. It is possible to load a high impedance line, but it is preferable to use a low impedance feed line which will reduce the voltage and radiation from the feeders. Feeding a doublet antenna with 72 Ω coax is an example of a low impedance match, when used on the band for which it is cut.

Attempting to load the transmitter to an improper antenna will cause high percentages of reflected power to flow in the final tank circuit. This may damage the components in the final stage. Usually, a mismatched antenna will also be more conducive to television interference and the amateur may be well advised in the case of persistent TVI to experiment with various antennas and feed lines. Also a loose contact or any shorting in the antenna system will cause interference.

Balanced antenna systems should be fed through an antenna coupler so that neither leg of the line nor the antenna will be at ground potential. Normally the output of the transmitter is unbalanced since one side of the output circuit is grounded.

When loading to either a balanced or an unbalanced system, the maximum loading point of 125 milliamperes in the final stage should not be exceeded. In many instances, the transmitter will load to a higher level, but the harmonic suppression of the pi network is better if the output coupling capacitor is not reduced to absolute minimum value. Then too, the extra 5 or 10 watts which would be gained by maximum loading would not make any detectable difference at the receiving end of the transmission.

END FED HERTZ AND MARCONI ANTENNAS

This type of antenna consists merely of a single wire from one-fourth wave length long to any even multiple thereof. One end of the wire is coupled to the transmitter and the other end supported in space. If this antenna is operated against ground, it is known as a Marconi antenna, while if the length is one-half wave length or more, it is known as a Hertz antenna. The greatest disadvantage of feeding a single wire is the necessity of bringing part of the radiating element into the radio room where its proximity to nearby objects increases losses. The greatest advantage of such an antenna is the simplicity with which it may be constructed and its compact size where space is at a premium. Providing the reactance of such antennas is not excessive they may be loaded satisfactorily with the pi network output circuit of the DX-40.

The length of such antennas can be calculated from the information given in the Radio Handbook or the ARRL Antenna Manual. Random lengths may also be used effectively except for some critical antenna lengths where the antenna impedance becomes too high or too low to be matched satisfactorily at the output of the transmitter. When such a situation is encountered it can usually be recognized by the action of the loading control on the transmitter. Should it be found that increasing the loading (reducing the antenna tuning capacitor value) does not raise the final amplifier plate current reading on the meter and yet the final amplifier has not become fully loaded, it is very likely that the antenna being used has a higher than normal reactance at the frequency of operation, resulting in the transmitter looking into a higher overall impedance.

If it is found that a change in the antenna tuning capacitor value has little effect on the final amplifier loading and does not affect the final amplifier tuning in the normal fashion, the antenna in use is probably presenting lower than normal impedance to the transmitter.

BALANCED ANTENNA FEEDERS AND SYSTEMS

In the average station it will be found expedient to have the radiating portion of the antenna some distance from the transmitter. This statement assumes that the amateur will have his antenna up high and clear of nearby objects, whereas the actual transmitter may be in the basement or any other room in the home. In such a case, some form of transmission line must be used to efficiently connect the transmitter to the antenna. In many instances, the transmission line is of the "balanced" type in which neither leg of the line is grounded. Such transmission lines may be either tuned or untuned, but in either case, a balanced line must be fed through an antenna coupler or "balun" coils. The coupler also provides the means for matching the impedance of the antenna, which will vary depending upon the type of antenna employed. A typical antenna coupler circuit is shown in Figure 22.

Basically the antenna coupler is an impedance transformer, transforming the impedance of the transmitter to the impedance of the transmission line.

Referring to Figure 22, coil L1 should match the impedance of the coaxial cable as closely as possible at the frequency of operation. The circuit consisting of L2, C1 and C2 must tune to the transmitter frequency. If it is desired to series tune the antenna, the shorting bar between 3 and 4 is opened and the transmission line connected at these points. For parallel tuning, 3 is shorted to 4 and the transmission line connected to 1 and 2. Taps are provided on coil L2 to facilitate matching the transmission line.

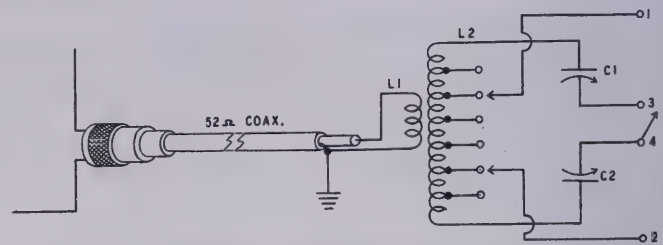


Figure 22

Such a unit can be built up from this or other suggested circuits or may be purchased commercially as a completed unit. In any case, feeding folded dipoles, end-fed "Zepps" and similar antenna types will require an antenna coupler or balun coils since the normal output of the DX-40 is designed for single-ended, unbalanced operation.

There are countless variables which affect the proper operation of an antenna. For example, one leg or section, or the entire antenna may be in close proximity to a large metal body such as a metal covered roof, the steel framework of buildings, eavestroughs, pipes, and other wires, etc. This would cause an unbalance and more difficult loading and have the result of absorbing a good deal of the radiated RF energy which would limit the transmitter's ability to "get out".

The Heath Company would rather not make recommendations as to the kind of antenna you should use. There are many that will work and each has its own characteristics. In general, a tuned antenna fed with untuned feeders can be connected directly to the transmitter. The antenna should be cut to one-half wave length for the frequency and fed in the center with 72Ω coax.

A Folded Dipole type of antenna can be used if it is cut to one-half wave length at the operating frequency and fed with balanced lines. However, Balun coils should be used such as the Heath-kit Balun Coil Set.

The long wire type of antenna is considered high impedance when end fed. For best results, it should be equal to one-half wave length at the lowest operating frequency and connected to the transmitter through a suitable antenna coupler.

Certain types of off-center fed antennas are not recommended for use with the DX-40 without the proper use of Baluns.

Harmonic radiation or TVI in some cases has been traced to an improper antenna or an incorrectly loaded antenna. Be sure your final stage tuning is dipped to the proper point of resonance. A strong second harmonic can usually be corrected by the use of an antenna that is not resonant to the second harmonic. A Folded Dipole antenna cut to one-half wave length at the operating frequency and fed through Balun Coils will usually correct this condition.

Needless to say, no attempt has been made here to cover the theory of antennas, as such, since much has been written on this subject. The possibilities in different antenna types and different feed systems are many and the factors mentioned herein only scratch the surface of the subject. Each operator will need to do his own investigation into the advantages and disadvantages of the various systems to determine just which one will best suit his needs. Basic data is available through the Radio Amateur Handbooks and other technical publications.

Some formulas that should prove helpful are listed as follows:

$$1 \text{ wave length in space} = \frac{300,000 \text{ meters}}{F_{kc}}$$

$$\text{Center fed dipole one-half wave long (length in feet)} = \frac{468}{F_{mc}}$$

$$\text{Folded dipole one-half wave long (length in feet)} = \frac{462}{F_{mc}}$$

$$\text{Zepp antenna one-half wave long (length in feet)} = \frac{492}{F_{mc}}$$

LOW PASS FILTERS: The harmonic rejection of the pi network output circuit of the DX-40 is excellent and will attenuate harmonics considerably when the transmitter is properly grounded and carefully tuned. However, additional harmonic attenuation may be had with the use of a low-pass filter between the output of the transmitter and the feed line or antenna. Such a filter should be designed to handle the maximum power output of the transmitter and must be operated into its nominal impedance.

An instrument to determine standing wave ratio on the feed line is a necessity in every ham shack. The HEATHKIT® Reflected Power Meter serves this purpose, and may be left permanently connected in the feed line of any amateur transmitter.

While the above instrument is preferred, the HEATHKIT® Power Meter will indicate maximum power output when tuning the transmitter. It will not indicate standing wave ratio, and is recommended only as a tuning aid.

Additional information on antennas can be found in:

Radio Amateurs Handbook - ARRL

The Antenna Handbook - ARRL

The Radio Handbook - Editors and Engineers, Ltd.

The Antenna Manual - Editors and Engineers, Ltd.

The Beam Antenna Handbook - Radio Publications

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-1	2	47 Ω 1/2 watt
1-9	1	1000 Ω 1/2 watt
1-10B	1	47 K Ω 2 watt
1-13	1	2700 Ω 1/2 watt
1-16	1	4700 Ω 1/2 watt
1-26	2	100 K Ω 1/2 watt
1-33	3	470 K Ω 1/2 watt
1-35	3	1 megohm 1/2 watt
1-37	1	2.2 megohm 1/2 watt
1-40	1	10 megohm 1/2 watt
1-46A	3	27 K Ω 1 watt
1B-15	1	1000 Ω 2 watt
2-127	1	.67 Ω 1% precision
2-128	1	20 Ω 1% precision
3E-2	1	10 K Ω 5 watt
3J-8	1	15 K Ω 10 watt
3J-9	2	20 K Ω 10 watt

Capacitors

20-1	2	47 $\mu\mu\text{f}$ silver mica
20-32	1	100 $\mu\mu\text{f}$ 1000 V
20-39	1	220 $\mu\mu\text{f}$ silver mica
20-41	1	22 $\mu\mu\text{f}$ silver mica
20-48	1	.001 $\mu\mu\text{f}$ 2 kv mica
20-61	1	27 $\mu\mu\text{f}$ mica
21-9	1	100 $\mu\mu\text{f}$ disc ceramic
21-13	1	500 $\mu\mu\text{f}$ disc ceramic
21-31	3	.02 μf disc ceramic
21-35	1	.005 μf 1.6 kv disc ceramic
21-43	4	.001 μf 1 kv disc ceramic
21-49	1	68 $\mu\mu\text{f}$ 4 kv disc ceramic
21-52	22	.002 μf 1 kv disc ceramic
21-71	4	.001 μf GMV 1400 V
23-11	1	.1 μf 600 V paper
23-15	1	.5 μf 400 V paper
25-36	2	40 μf 450 V electrolytic
26-9	1	450 $\mu\mu\text{f}$ variable (dual)
26-24	1	20 $\mu\mu\text{f}$ variable
26-31	1	140 $\mu\mu\text{f}$ variable

Coils-Chokes-Transformers

40-86	1	Amplifier plate coil
40-104	1	40 meter oscillator coil
40-105	1	80 meter buffer coil
40-106	1	40 meter buffer coil
40-107	1	20 meter buffer coil
40-108	1	15 meter buffer coil
40-109	1	10 meter buffer coil
45-4	2	1.1 mh RF choke
45-19	1	Parasitic choke
45-28	2	Line choke
45-41	1	.425 mh RF choke
46-12	1	7 henry 150 ma filter choke
54-38	1	Power transformer

PART No.	PARTS Per Kit	DESCRIPTION
Switches-Meters-Tubes		
60-2	1	DPDT slide switch
63-115	1	Crystal switch
63-139	1	Operations switch
63-140	1	Bandswitch
407-46	1	1 milliamperere meter
411-2	1	5U4GB tube
411-26	1	12AX7 tube
411-63	2	6CL6 tube
411-75	1	6146 tube
411-109	1	6DE7 tube
412-1	1	#47 pilot light
413-2	1	Pilot light jewel

Terminal Strips-Sockets-Knobs

431-2	3	2 lug terminal strip
431-3	1	3 lug terminal strip
431-10	4	3 lug terminal strip
431-11	1	5 lug terminal strip
431-12	2	4 lug terminal strip
431-15	1	1 lug terminal strip
431-16	3	2 lug terminal strip
431-26	1	1 lug terminal strip
432-3	1	Microphone connector
434-21	1	Pilot light socket
434-38	3	Crystal socket
434-39	3	Octal socket
434-42	1	Phono socket
434-43	1	9 pin shield socket
434-56	2	9 pin socket
434-75	1	9 pin (ceramic) socket
436-4	1	Phone jack
436-5	1	Coaxial jack
100-M54	2	Pointer knob, large
462-19	3	Gray knob, small
462-36	1	Red knob, small

Miscellaneous

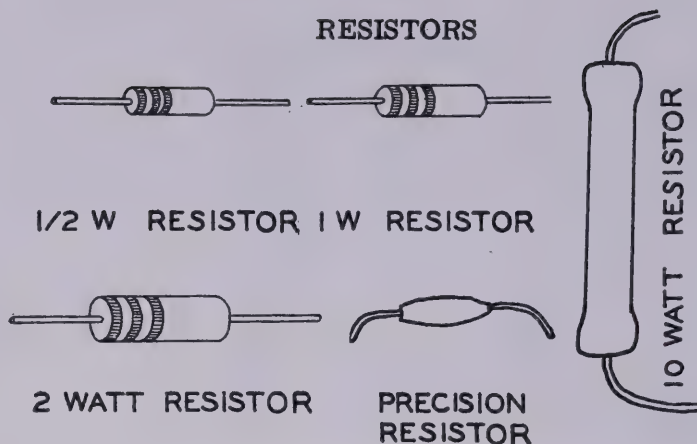
71-2	2	Feedthrough insulator
73-1	2	3/8" Rubber grommet
73-3	1	1/2" Rubber grommet
73-4	5	5/16 Rubber grommet
89-1	1	Line cord
100-105	1	Cable assembly
260-10	1	Ceramic plate cap
261-6	4	Rubber feet
340-1	1	Length #14 tinned wire
340-2	1	Length #20 tinned wire
340-3	1	Length #16 tinned wire
343-2	1	Length coaxial cable
343-3	1	Length shield wire
344-1	3	Lengths hookup wire (gray, green, yellow)
346-1	1	Length sleeving
391-3	1	Logotype (silver)
453-22	1	Shaft extention
595-180	1	Instruction manual

PART No.	PARTS Per Kit	DESCRIPTION
Metal Parts		
90-68	1	Cabinet
200M136	1	Chassis
203-133-F171	1	Front panel
204-M137	1	Shield bracket
204-M138	1	Switch support
206-3	1	Tube shield
206-43	1	Coaxial shield
206-54	1	Tube shield 2 3/8"
206-55	1	Tube shield base
206-56	1	Meter shield
206-M59	1	Shield Plate

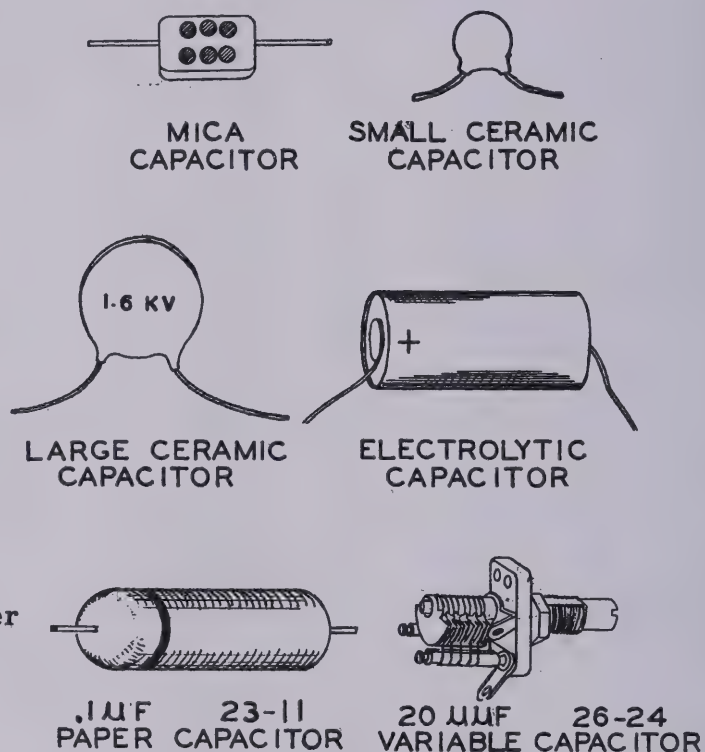
Hardware

250-4	4	4-40 3/8 RHMS
250-8	11	#6 sheet metal screw
250-9	9	6-32 x 3/8 RHMS
250-18	13	8-32 x 3/8 RHMS
250-31	22	6-32 x 1/4 RHMS
250-33	1	#6 1/8" set screw
250-34	3	4-40 x 1/2" RHMS
250-48	2	6-32 x 1/2" RHMS
250-49	8	3-48 x 1/4 BHMS
250-54	1	10-32 x 5/8 RHMS
251-1	3	6-32 spade bolt
252-1	8	3-48 nut
252-2	4	4-40 nut
252-3	29	6-32 nut
252-4	13	8-32 nut
252-5	2	#10-32 nut
252-7	5	3/8-32 control nut
252-15	3	4-40 x 3/16 nut
253-1	1	#6 fiber flat washer
253-3	2	#10 fiber flat washer
253-7	2	#10 fiber shoulder washer
253-10	5	3/8 flat washer
254-1	33	#6 lockwasher
254-2	18	#8 lockwasher
254-3	1	#10 lockwasher
254-4	4	3/8" lockwasher
254-7	8	#3 lockwasher
255-13	2	#6 1/4" spacer
259-1	7	#6 solder lug

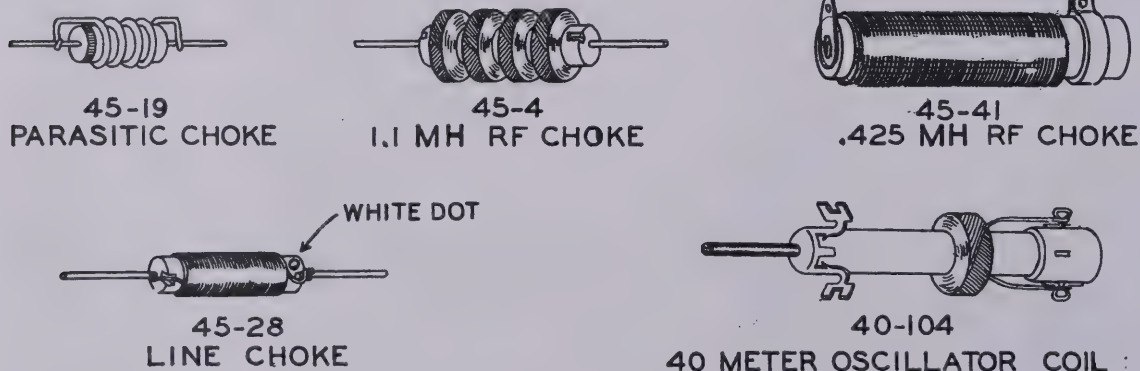
RESISTORS



CAPACITORS



CHOKES



The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

SERVICE

If, after applying the information contained in this manual and your best efforts on the unit, you are still unable to obtain proper performance from the Transmitter, it is suggested that you take advantage of the technical facilities which the Heath Company makes available to its customers.

The Technical Consultation Department is maintained for the purpose of providing Heath customers with a personalized technical consultation service; this service is available to you without charge. The technical consultants are thoroughly familiar with all details of the Transmitter and can usually localize the trouble from a suitable description of the difficulty encountered. It is, of course, necessary that you provide full and complete information concerning your problem when writing to the Technical Consultation Department for assistance. For instance, clearly identify the kit involved, giving the purchase date and, if possible, the invoice number; describe in detail the difficulty that you have encountered; state what you have attempted to do to rectify the trouble, what results have been achieved, and include any information or clues that you feel could possibly be of value to the consultant who handles your problem. Failure to provide complete descriptive details may lead to incorrect assumptions on the part of the consultant and needless delay in the solution to your problem. Quite frequently, when the information given the consultants is complete, concise and reliable, a diagnosis of the difficulty can be made with confidence and specific instructions given for its correction. If replacement of a component is involved in the correction, the component will be shipped to you, subject to the terms and conditions of the Warranty.

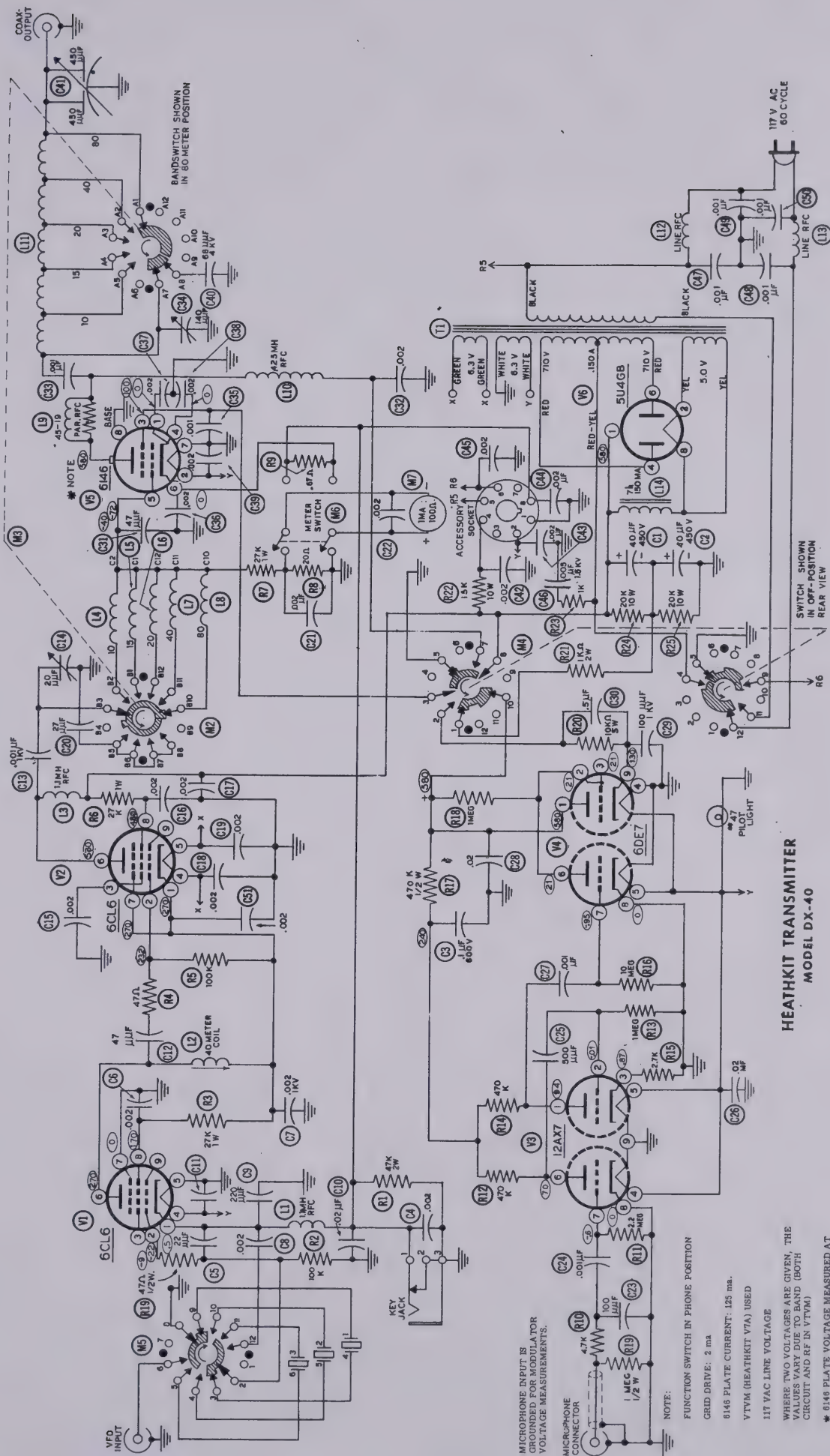
The Factory Service facilities are also available to you, in case you are not familiar enough with electronics to provide our consultants with sufficient information on which to base a diagnosis of your difficulty, or in the event that you prefer to have the difficulty corrected in this manner. You may return the completed Transmitter to the Heath Company for inspection and necessary repairs and adjustments. You will be charged a fixed fee of \$8.00, plus the price of any additional parts or material required. However, if the Transmitter is returned within the Warranty period, parts charges will be governed by the terms of the Warranty. State the date of purchase and give invoice number, if possible.

Local Service by Authorized Heathkit Dealers is also available and often will be your fastest, most efficient method of obtaining service for your Heathkits. Although you may find charges for local service somewhat higher than those listed in Heathkit manuals (for factory service), the amount of increase is usually offset by the transportation charges you would pay if you elected to return your kit to the Heath Company.

Heathkit dealers will honor the regular 90 day Heathkit Parts Warranty on all kits, whether purchased through a dealer or directly from Heath Company. It will be necessary that you verify the purchase date of your kit by presenting your copy of the Heath Company invoice to the authorized dealer involved.

Under the conditions specified in the Warranty, replacement parts are supplied without charge; however, if your local dealer assists you in locating a defective part (or parts) in your Heathkit, or installs a replacement part for you, he may charge you for this service.

Heathkits purchased locally and returned to Heath Company for service must be accompanied by your copy of the dated sales receipt from your authorized Heathkit dealer in order to be eligible for parts replacement under the terms of the Warranty.



PART OF
DX-40
DRAWING

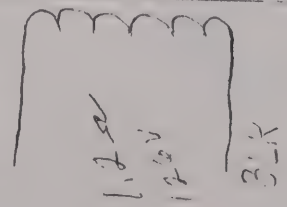
4 DIODES
1000V 2A.

YELLOW

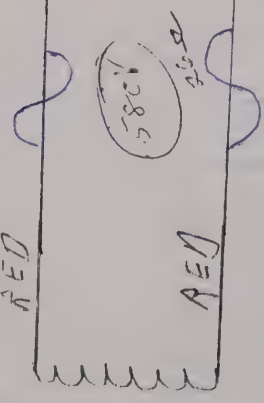
TAPE ENDS OR
DONUT USE

YELLOW

RD-32K

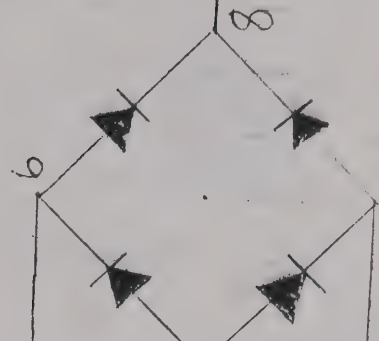


RED



4

6



8

2

GREEN TOY
FILAMENTS

6.3V 80 0.2

YL-GREEN

DONOT REMOVE PIN 8 TO L14 WIRE.
REMOVE ALL WIRE
FROM 5U4GB SOCKET
USE PIN 2, 4, 6, AND 8
FOR TIE

L14



TO
SW

R24

C1

R25

C2

A 6.3V FILAMENTS TRANSFORMER
MUST BE USED FOR V2
DO NOT TRY TO USE THIS TRANSFORMER
FOR V2 FILAMENTS.

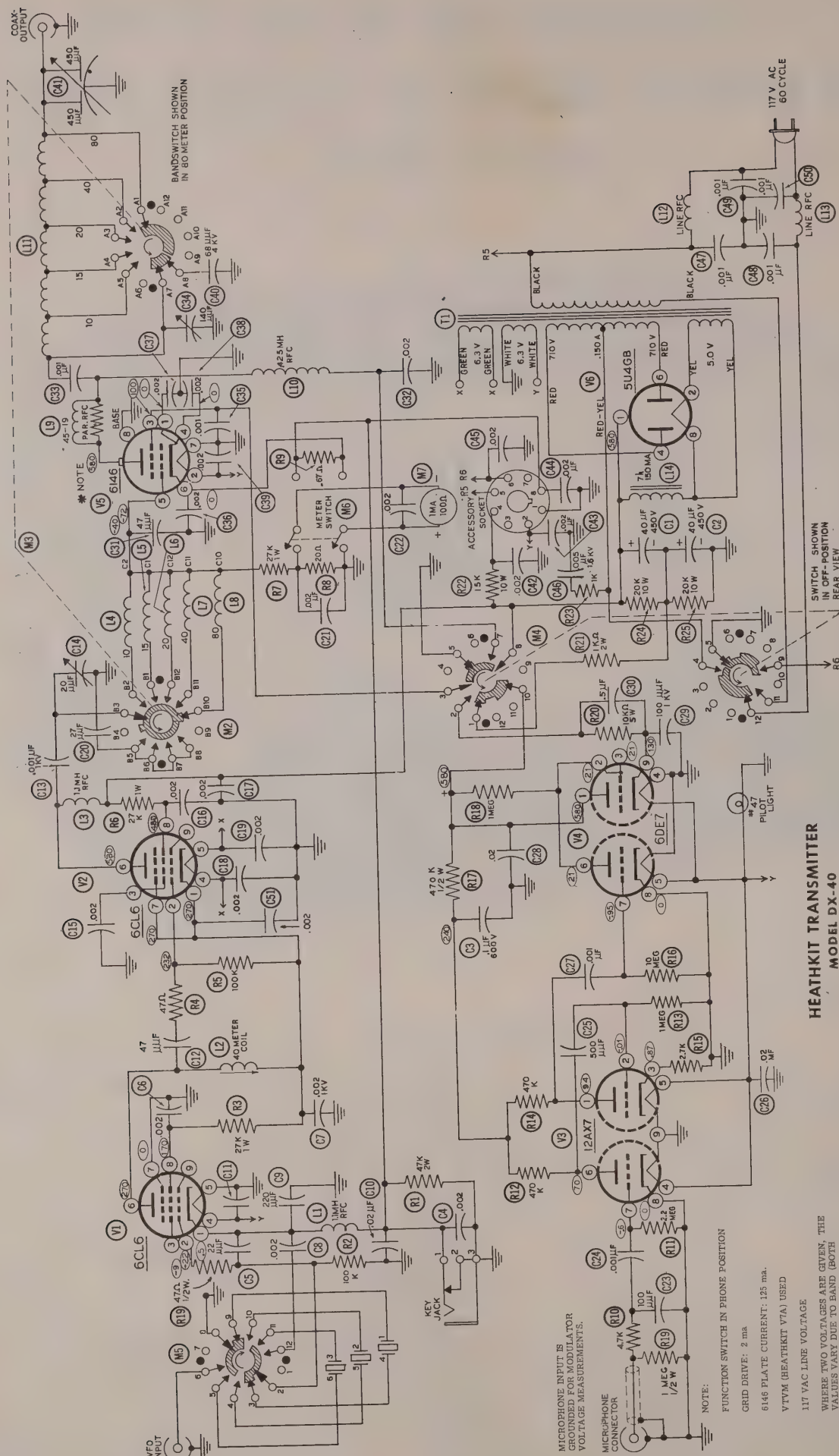
CONSTRUCTION MANUAL NO LONGER AVAILABLE

HEATHKIT AMATEUR TRANSMITTER MODEL DX-40



SPECIFICATIONS

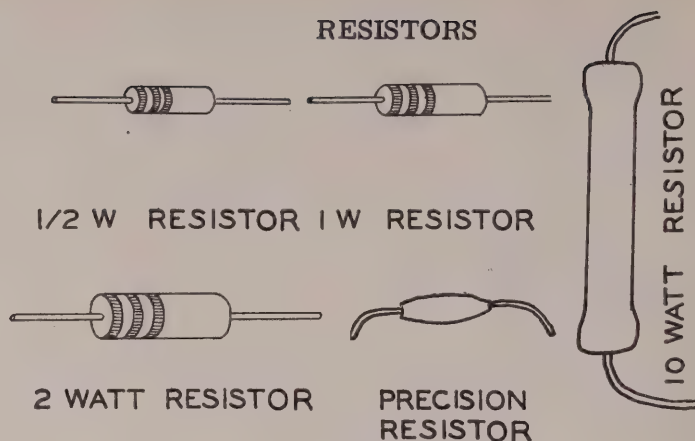
Power Input:	75 watt CW, 60 watt peak controlled carrier phone
Output Impedance:	50-600 Ω
Output Coupling:	Pi network (coaxial)
Operation:	Crystal-VFO, CW, Phone
Band Coverage:	80, 40, 20, 15, 10
Tube Complement:	5U4GB Rectifier 12AX7 Speech Amplifier 6DE7 Carrier Control, Modulator 6CL6 Crystal Oscillator 6CL6 Buffer 6146 Final Amplifier
Power Requirements:	117 volts AC, 60 cycles, 175 watts
Cabinet Size:	13" wide x 8 1/2" high x 9" deep
Net Weight:	21 lbs.
Shipping Weight:	26 lbs.



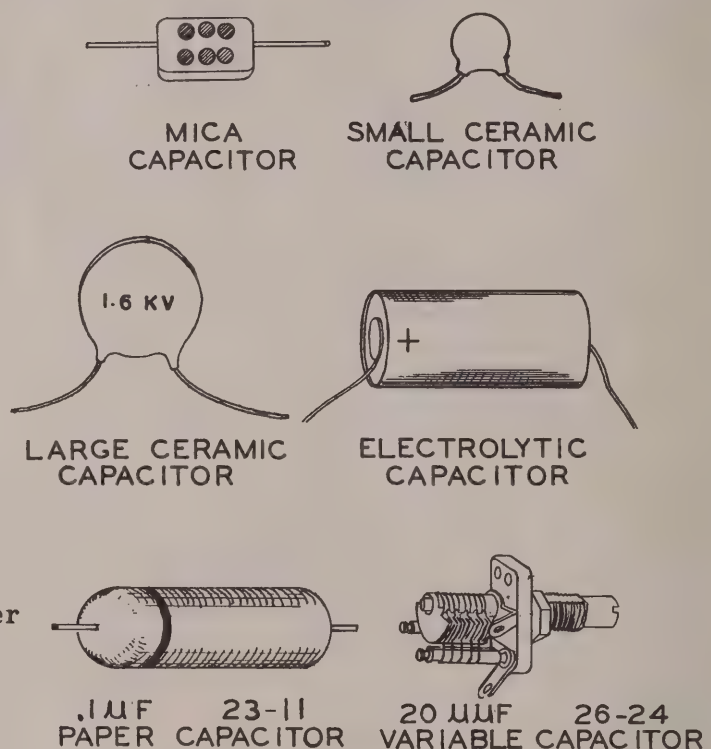
HEATHKIT TRANSMITTER
MODEL DX-40

PART No.	PARTS Per Kit	DESCRIPTION
Metal Parts		
90-68	1	Cabinet
200M136	1	Chassis
203-133-F171	1	Front panel
204-M137	1	Shield bracket
204-M138	1	Switch support
206-3	1	Tube shield
206-43	1	Coaxial shield
206-54	1	Tube shield 2 3/8"
206-55	1	Tube shield base
206-56	1	Meter shield
206-M59	1	Shield Plate
Hardware		
250-4	4	4-40 3/8 RHMS
250-8	11	#6 sheet metal screw
250-9	9	6-32 x 3/8 RHMS
250-18	13	8-32 x 3/8 RHMS
250-31	22	6-32 x 1/4 RHMS
250-33	1	#6 1/8" set screw
250-34	3	4-40 x 1/2" RHMS
250-48	2	6-32 x 1/2" RHMS
250-49	8	3-48 x 1/4 BHMS
250-54	1	10-32 x 5/8 RHMS
251-1	3	6-32 spade bolt
252-1	8	3-48 nut
252-2	4	4-40 nut
252-3	29	6-32 nut
252-4	13	8-32 nut
252-5	2	#10-32 nut
252-7	5	3/8-32 control nut
252-15	3	4-40 x 3/16 nut
253-1	1	#6 fiber flat washer
253-3	2	#10 fiber flat washer
253-7	2	#10 fiber shoulder washer
253-10	5	3/8 flat washer
254-1	33	#6 lockwasher
254-2	18	#8 lockwasher
254-3	1	#10 lockwasher
254-4	4	3/8" lockwasher
254-7	8	#3 lockwasher
255-13	2	#6 1/4" spacer
259-1	7	#6 solder lug

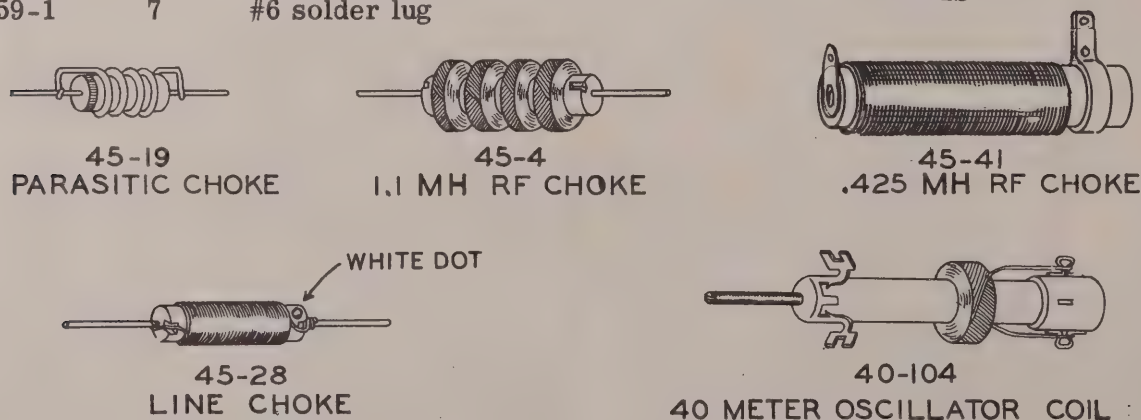
RESISTORS



CAPACITORS



CHOKES



PART No.	PARTS Per Kit	DESCRIPTION	PART No.	PARTS Per Kit	DESCRIPTION
Resistors			Switches-Meters-Tubes		
1-1	2	47Ω 1/2 watt	60-2	1	DPDT slide switch
1-9	1	1000Ω 1/2 watt	63-115	1	Crystal switch
1-10B	1	47 KΩ 2 watt	63-139	1	Operations switch
1-13	1	2700Ω 1/2 watt	63-140	1	Bandswitch
1-16	1	4700Ω 1/2 watt	407-46	1	1 milliamperere meter
1-26	2	100 KΩ 1/2 watt	411-2	1	5U4GB tube
1-33	3	470 KΩ 1/2 watt	411-26	1	12AX7 tube
1-35	3	1 megohm 1/2 watt	411-63	2	6CL6 tube
1-37	1	2.2 megohm 1/2 watt	411-75	1	6146 tube
1-40	1	10 megohm 1/2 watt	411-109	1	6DE7 tube
1-46A	3	27 KΩ 1 watt	412-1	1	#47 pilot light
1B-15	1	1000Ω 2 watt	413-2	1	Pilot light jewel
2-127	1	.67Ω 1% precision	Terminal Strips-Sockets-Knobs		
2-128	1	20Ω 1% precision	431-2	3	2 lug terminal strip
3E-2	1	10 KΩ 5 watt	431-3	1	3 lug terminal strip
3J-8	1	15 KΩ 10 watt	431-10	4	3 lug terminal strip
3J-9	2	20 KΩ 10 watt	431-11	1	5 lug terminal strip
Capacitors			431-12	2	4 lug terminal strip
20-1	2	47 μμf silver mica	431-15	1	1 lug terminal strip
20-32	1	100 μμf 1000 V	431-16	3	2 lug terminal strip
20-39	1	220 μμf silver mica	431-26	1	1 lug terminal strip
20-41	1	22 μμf silver mica	432-3	1	Microphone connector
20-48	1	.001 μμf 2 kv mica	434-21	1	Pilot light socket
20-61	1	27 μμf mica	434-38	3	Crystal socket
21-9	1	100 μμf disc ceramic	434-39	3	Octal socket
21-13	1	500 μμf disc ceramic	434-42	1	Phono socket
21-31	3	.02 μf disc ceramic	434-43	1	9 pin shield socket
21-35	1	.005 μf 1.6 kv disc ceramic	434-56	2	9 pin socket
21-43	4	.001 μf 1 kv disc ceramic	434-75	1	9 pin (ceramic) socket
21-49	1	68 μμf 4 kv disc ceramic	436-4	1	Phone jack
21-52	22	.002 μf 1 kv disc ceramic	436-5	1	Coaxial jack
21-71	4	.001 μf GMV 1400 V	100-M54	2	Pointer knob, large
23-11	1	.1 μf 600 V paper	462-19	3	Gray knob, small
23-15	1	.5 μf 400 V paper	462-36	1	Red knob, small
25-36	2	40 μf 450 V electrolytic	Miscellaneous		
26-9	1	450 μμf variable (dual)	71-2	2	Feedthrough insulator
26-24	1	20 μμf variable	73-1	2	3/8" Rubber grommet
26-31	1	140 μμf variable	73-3	1	1/2" Rubber grommet
Coils-Chokes-Transformers			73-4	5	5/16 Rubber grommet
40-86	1	Amplifier plate coil	89-1	1	Line cord
40-104	1	40 meter oscillator coil	100-105	1	Cable assembly
40-105	1	80 meter buffer coil	260-10	1	Ceramic plate cap
40-106	1	40 meter buffer coil	261-6	4	Rubber feet
40-107	1	20 meter buffer coil	340-1	1	Length #14 tinned wire
40-108	1	15 meter buffer coil	340-2	1	Length #20 tinned wire
40-109	1	10 meter buffer coil	340-3	1	Length #16 tinned wire
45-4	2	1.1 mh RF choke	343-2	1	Length coaxial cable
45-19	1	Parasitic choke	343-3	1	Length shield wire
45-28	2	Line choke	344-1	3	Lengths hookup wire (gray, green, yellow)
45-41	1	.425 mh RF choke	346-1	1	Length sleeving
46-12	1	7 henry 150 ma filter choke	391-3	1	Logotype (silver)
54-38	1	Power transformer	453-22	1	Shaft extention
			595-180	1	Instruction manual

Needless to say, no attempt has been made here to cover the theory of antennas, as such, since much has been written on this subject. The possibilities in different antenna types and different feed systems are many and the factors mentioned herein only scratch the surface of the subject. Each operator will need to do his own investigation into the advantages and disadvantages of the various systems to determine just which one will best suit his needs. Basic data is available through the Radio Amateur Handbooks and other technical publications.

Some formulas that should prove helpful are listed as follows:

$$1 \text{ wave length in space} = \frac{300,000 \text{ meters}}{F_{kc}}$$

$$\text{Center fed dipole one-half wave long (length in feet)} = \frac{468}{F_{mc}}$$

$$\text{Folded dipole one-half wave long (length in feet)} = \frac{462}{F_{mc}}$$

$$\text{Zepp antenna one-half wave long (length in feet)} = \frac{492}{F_{mc}}$$

LOW PASS FILTERS: The harmonic rejection of the pi network output circuit of the DX-40 is excellent and will attenuate harmonics considerably when the transmitter is properly grounded and carefully tuned. However, additional harmonic attenuation may be had with the use of a low-pass filter between the output of the transmitter and the feed line or antenna. Such a filter should be designed to handle the maximum power output of the transmitter and must be operated into its nominal impedance.

An instrument to determine standing wave ratio on the feed line is a necessity in every ham shack. The HEATHKIT® Reflected Power Meter serves this purpose, and may be left permanently connected in the feed line of any amateur transmitter.

While the above instrument is preferred, the HEATHKIT® Power Meter will indicate maximum power output when tuning the transmitter. It will not indicate standing wave ratio, and is recommended only as a tuning aid.

Additional information on antennas can be found in:

Radio Amateurs Handbook - ARRL

The Antenna Handbook - ARRL

The Radio Handbook - Editors and Engineers, Ltd.

The Antenna Manual - Editors and Engineers, Ltd.

The Beam Antenna Handbook - Radio Publications

BALANCED ANTENNA FEEDERS AND SYSTEMS

In the average station it will be found expedient to have the radiating portion of the antenna some distance from the transmitter. This statement assumes that the amateur will have his antenna up high and clear of nearby objects, whereas the actual transmitter may be in the basement or any other room in the home. In such a case, some form of transmission line must be used to efficiently connect the transmitter to the antenna. In many instances, the transmission line is of the "balanced" type in which neither leg of the line is grounded. Such transmission lines may be either tuned or untuned, but in either case, a balanced line must be fed through an antenna coupler or "balun" coils. The coupler also provides the means for matching the impedance of the antenna, which will vary depending upon the type of antenna employed. A typical antenna coupler circuit is shown in Figure 22.

Basically the antenna coupler is an impedance transformer, transforming the impedance of the transmitter to the impedance of the transmission line.

Referring to Figure 22, coil L1 should match the impedance of the coaxial cable as closely as possible at the frequency of operation. The circuit consisting of L2, C1 and C2 must tune to the transmitter frequency. If it is desired to series tune the antenna, the shorting bar between 3 and 4 is opened and the transmission line connected at these points. For parallel tuning, 3 is shorted to 4 and the transmission line connected to 1 and 2. Taps are provided on coil L2 to facilitate matching the transmission line.

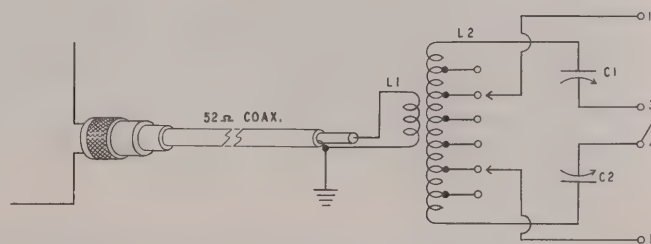


Figure 22

Such a unit can be built up from this or other suggested circuits or may be purchased commercially as a completed unit. In any case, feeding folded dipoles, end-fed "Zepps" and similar antenna types will require an antenna coupler or balun coils since the normal output of the DX-40 is designed for single-ended, unbalanced operation.

There are countless variables which affect the proper operation of an antenna. For example, one leg or section, or the entire antenna may be in close proximity to a large metal body such as a metal covered roof, the steel framework of buildings, eavestroughs, pipes, and other wires, etc. This would cause an unbalance and more difficult loading and have the result of absorbing a good deal of the radiated RF energy which would limit the transmitter's ability to "get out".

The Heath Company would rather not make recommendations as to the kind of antenna you should use. There are many that will work and each has its own characteristics. In general, a tuned antenna fed with untuned feeders can be connected directly to the transmitter. The antenna should be cut to one-half wave length for the frequency and fed in the center with 72Ω coax.

A Folded Dipole type of antenna can be used if it is cut to one-half wave length at the operating frequency and fed with balanced lines. However, Balun coils should be used such as the Heath-kit Balun Coil Set.

The long wire type of antenna is considered high impedance when end fed. For best results, it should be equal to one-half wave length at the lowest operating frequency and connected to the transmitter through a suitable antenna coupler.

Certain types of off-center fed antennas are not recommended for use with the DX-40 without the proper use of Baluns.

Harmonic radiation or TVI in some cases has been traced to an improper antenna or an incorrectly loaded antenna. Be sure your final stage tuning is dipped to the proper point of resonance. A strong second harmonic can usually be corrected by the use of an antenna that is not resonant to the second harmonic. A Folded Dipole antenna cut to one-half wave length at the operating frequency and fed through Balun Coils will usually correct this condition.

THE ANTENNA

NOTE: How important a part the antenna plays in attaining the final result required of a transmitter cannot be stressed too strongly. Any additional effort spent to obtain an "ideal" antenna will more than pay for itself in making possible many satisfactory "over the air" contacts.

The pi network output circuit of the Model DX-40 will match pure resistive loads from approximately 50 to 1000 Ω , and will eliminate the need for an antenna coupler when used with nominal impedance feed lines. The transmitter will match antennas and unbalanced lines within these limits provided such antennas or lines are nonreactive. Reactive antennas or lines present a somewhat different problem since the reactance takes the form of impedance which may raise or lower the antenna impedance beyond the matching range of the transmitter output circuit. It is possible to load a high impedance line, but it is preferable to use a low impedance feed line which will reduce the voltage and radiation from the feeders. Feeding a doublet antenna with 72 Ω coax is an example of a low impedance match, when used on the band for which it is cut.

Attempting to load the transmitter to an improper antenna will cause high percentages of reflected power to flow in the final tank circuit. This may damage the components in the final stage. Usually, a mismatched antenna will also be more conducive to television interference and the amateur may be well advised in the case of persistent TVI to experiment with various antennas and feed lines. Also a loose contact or any shorting in the antenna system will cause interference.

Balanced antenna systems should be fed through an antenna coupler so that neither leg of the line nor the antenna will be at ground potential. Normally the output of the transmitter is unbalanced since one side of the output circuit is grounded.

When loading to either a balanced or an unbalanced system, the maximum loading point of 125 milliamperes in the final stage should not be exceeded. In many instances, the transmitter will load to a higher level, but the harmonic suppression of the pi network is better if the output coupling capacitor is not reduced to absolute minimum value. Then too, the extra 5 or 10 watts which would be gained by maximum loading would not make any detectable difference at the receiving end of the transmission.

END FED HERTZ AND MARCONI ANTENNAS

This type of antenna consists merely of a single wire from one-fourth wave length long to any even multiple thereof. One end of the wire is coupled to the transmitter and the other end supported in space. If this antenna is operated against ground, it is known as a Marconi antenna, while if the length is one-half wave length or more, it is known as a Hertz antenna. The greatest disadvantage of feeding a single wire is the necessity of bringing part of the radiating element into the radio room where its proximity to nearby objects increases losses. The greatest advantage of such an antenna is the simplicity with which it may be constructed and its compact size where space is at a premium. Providing the reactance of such antennas is not excessive they may be loaded satisfactorily with the pi network output circuit of the DX-40.

The length of such antennas can be calculated from the information given in the Radio Handbook or the ARRL Antenna Manual. Random lengths may also be used effectively except for some critical antenna lengths where the antenna impedance becomes too high or too low to be matched satisfactorily at the output of the transmitter. When such a situation is encountered it can usually be recognized by the action of the loading control on the transmitter. Should it be found that increasing the loading (reducing the antenna tuning capacitor value) does not raise the final amplifier plate current reading on the meter and yet the final amplifier has not become fully loaded, it is very likely that the antenna being used has a higher than normal reactance at the frequency of operation, resulting in the transmitter looking into a higher overall impedance.

If it is found that a change in the antenna tuning capacitor value has little effect on the final amplifier loading and does not affect the final amplifier tuning in the normal fashion, the antenna in use is probably presenting lower than normal impedance to the transmitter.

Antenna Tuning Condenser, the antenna impedance is not proper and should be checked. This is also true if it will not dip at all. The easiest test for this condition is to substitute a dummy load, (a 115 volt, 60-watt bulb) for the antenna.

NOTE: Feeding a very low impedance antenna, especially at the low frequency end of the 80-meter band may require additional capacity, such as a .001 μ f (large size mica) connected across the coax output connector to allow a proper "dip" in plate current. This may be done with a coax "T" connector if required. CAUTION: Remove this capacitor before attempting operation on any other band as it will make it impossible to "load" the antenna.

CREEPING PLATE CURRENT will usually indicate a "soft" 6146 final amplifier tube. Loss of grid drive usually accompanies this condition. This is usually caused by consistent operation of the 6146 tube in an overloaded condition. Plate voltage reading will be the total B+ voltage which can be read at Pin #1 on the 5U4GB rectifier socket E and should be near 600 volts. Once again, use caution in testing high voltages. The screen voltage (with no modulation) should be about 100 volts.

SPEECH AMPLIFIER AND MODULATOR STAGES

TUBE A -- 12AX7 Dual Triode

TUBE B -- 6DE7 Dual Dissimilar Triode

1. Test the 12AX7 tube A, and the 6DE7 tube B, by substitution.
2. With the line cord disconnected, test the resistance between the ungrounded end of the .1 μ f paper capacitor (lug #1 on terminal strip BB) and the chassis. It should read approximately 500 K Ω on the OFF and PHONE positions. The other switch positions should show no readings.
3. Inspect all pin connections on the tube sockets for poor solder connections.
4. Recheck the step-by-step wiring and be sure that components and leads are connected to the correct numbered pin connections on the sockets.
5. With a crystal plugged in, the power on and the transmitter tuned for CW conditions, switch to PHONE position. Measure the voltage from lug #1 on terminal strip BB to the chassis. It should read approximately 230 volts, as read on a Heathkit VTVM. The plate voltage on the first triode section of the 12AX7, read from pin #6 to the chassis with the VTVM, should be about 70 volts on the 150 volt scale, and the grid voltage near -.6 volts on the 1.5 volt scale, read from pin #7 to the chassis. The second triode plate, from pin #1 to chassis, should read about 90 volts. The first triode cathode is grounded. Voltage reading on the 12AX7 second triode cathode should be about .9 volts, measured across the 2.7 K Ω resistor, from pin #3 to the chassis.
6. Plate voltage on the 7 watt triode section of the 6DE7 should be approximately 580 volts. This is read from pin #1 of the 6DE7 to the chassis. This same voltage read from plate to cathode (pins #1 to #9) is about 460 volts. The plate voltage of the 1.5 watt driver triode is near 20 volts (with no modulation), read on the 50 volt scale of the VTVM, from pin #6 to chassis. The first triode cathode is grounded. Screen voltage for the 6146 final amplifier is obtained (through the 10 K Ω resistor) from the heavy duty triode section cathode, which is pin #9. The voltage at pin #9 to chassis is approximately 115 volts and at the 6146 screen grid pin #3 is near 100 volts with no modulation. The grid voltage read from pin #7 to chassis, with the VTVM, should be near -.9 volts.

METER CIRCUIT: A 100 Ω one milliamperere D'Arsonval movement meter is switched to read plate or grid current to the 6146 final amplifier tube. To avoid extreme excursions of the meter pointer while operation on CW, it may be advisable to leave it switched to the lower reading grid position.

The meter shield can serves to mount the meter as well as shielding any RF radiation through the meter hole which could cause TVI.

3. If little or no grid drive is available, there is the possibility that the small buffer coils have been interchanged. A rough check can be made by noting the size of the wire and apparent number of turns. Fine wire and more turns are used on the low frequency coils, with progressively larger wire and lesser turns as 10 meters is approached. Check each coil for a broken winding which would check "open" on an ohmmeter. Also, be sure the coil leads do not short to each other or to the switch frame.
4. WITH ALL POWER REMOVED, test the 1.1 mh RF choke which is connected in the plate circuit for an open winding.
5. With the line cord plugged in, high voltage will be indicated on all pins except 4 and 5 (if measurements are taken from the chassis). This is due to the buffer stage being operated in series with the oscillator stage. Voltage readings on the buffer stage should be taken from the tube cathode which is tied to lug #1 on terminal strip FF. CAUTION: Both meter leads will therefore be "alive". Plate voltage read from lug #1 on terminal strip GG should be approximately 350 to 400 volts (TUNE position), depending on the adjustment of the drive control. Screen voltage should be about 230 volts, also depending on the adjustment of the drive control. Approximately 6.3 volts AC should be indicated between filament pins 4 and 5 on socket D.

FINAL AMPLIFIER

TUBE F 6146

1. Test the 6146 tube G by substitution.
2. Grid drive should be approximately 3 ma. for proper operation.
3. WITH THE LINE CORD DISCONNECTED, check the .425 mh RF choke in the final plate circuit with an ohmmeter.
4. Tighten the nuts on the feedthrough insulators (top and bottom).
5. Inspect the antenna tuning condenser and the final amplifier condenser for shorts, such as solder drips from capacitor terminals shorting to the chassis.
6. Check the 68 μmf capacitor between the bandswitch terminal A8 and the grounded lug on the terminal strip. A swollen capacitor will indicate that the component has been damaged by excessive RF current due to trying to load an improper antenna impedance. The swelling of the capacitor will have decreased in its capacity and it will require replacement. This capacitor is only used in the circuit on the 80-meter band.
7. Inspect the connections of the final tank coil to the bandswitch. Make sure each is connected to the proper terminal on the switch.

GRID DRIVE to the final amplifier stage is essential to supply safe operating bias to the 6146. The final amplifier should not be on for more than a few seconds if no grid drive is indicated on the panel meter.

THE DRIVE CONTROL tunes only the upper and lower extremes of the band, no (outside) harmonics.

KEYING is accomplished by grounding the cathode of the Final Amplifier and the Oscillator stage. Poor solder connections in this circuit can cause erratic keying.

DIPPING the final is accomplished by tuning the stage to resonance or to minimum plate current indication. The antenna tuning or loading capacitor should be closed at "O" position before beginning to load an antenna. Dip the final to read minimum plate current, open the loading capacitor a little at a time, successively redipping the final until the final "dip" is at the recommended current value. If the dip is too low on the plate meter and it is impossible to load it with the

GENERAL SERVICE

SOLDERING: Cold and loose solder connections are a common source of trouble in assembling any piece of electronic equipment. Sometimes apparently good solder connections will have an insulating coating of rosin between the wire, the terminal and the solder. This type of defective soldering is very difficult to locate in the process of trouble-shooting, and the builder will do well to see that each wire in a connection point is firmly embedded in the solder. Many times when more than one wire is connected to a terminal or lug the lower wire will not receive sufficient heat or solder even though the connection looks satisfactory. Trouble can also be caused by being too generous with solder and heat, with a short resulting from solder running down the lug and touching the chassis or other components. Use extreme care when soldering to switch contact points, to avoid solder running too far and spoiling the spring tension of the contacts.

With miniature tube sockets there is a possibility of shorts between adjacent socket terminals due to the close spacing. This should be checked and if any doubt exists, the terminals should be pried apart until obvious spacing can be seen between them.

In general, do not rely on the solder itself to form the electrical connection. A firm metal to metal contact should be made before flowing the solder over it.

COMPONENTS: Any part that physically looks defective should be tested with the proper instrument.

TUBES: Tubes can be checked on a tube checker but the best method is by substitution. An extra set of tubes should be on hand for testing and to replace normal tube failures.

WIRING: Mistakes in wiring are the most common cause of difficulty. Consequently, the first step is to recheck all wiring against the pictorials and schematic diagrams. Often having a friend check the wiring will locate an error consistently overlooked.

Follow the construction manual and pictorials so that each lead is placed in its proper position. Make leads as short as possible, except where leads are measured or specifically routed around the edge of the chassis. This is to prevent adverse effects such as spurious RF oscillations and audio feedback.

CAUSE AND EFFECT: Be sure to reread the circuit description on page 3 so that "cause and effect" reasoning may be employed as the search for trouble progresses. If some difficulty still persists after the steps outlined have been completed, attempt to localize the trouble to a particular stage in the transmitter circuit. Use the tuning procedure as a basis for localization and refer to the block diagram and schematic to visualize circuit relationships. The panel meter and station receiver are valuable tools to use in locating trouble.

TRACING PROCEDURE: For the following tracing procedures, use the schematic diagram for reference.

If any activity is noted when the line cord is plugged in and the operation switch is in the OFF position the AC circuit should be traced. One side of the line cord is connected through a line choke to one side of the primary of the power transformer. The other side of the line cord is connected through a line choke to the blue cable wire which connects to terminal 11 of the operation switch; the black cable wire returns from switch terminal 12, to the other primary side of the transformer. Contacts 11 and 12, of the switch thus control line power to the transformer. Also check the four .001 μ f 1400 volt disc ceramic capacitors connected across the line for shorts.

If the tubes and pilot light do not light up when the operation switch is set to STANDBY position, again check the AC circuit with the line cord unplugged to determine why the transformer is not receiving power. If the tubes do light up with the power on and the meter reads in PLATE position, or some other indication of high voltage being applied is apparent, check the following. Unplug the line cord, then with an ohmmeter, check from #5 on KK to ground. It should read

Switching the operation switch to either the PHONE or CW position will provide the full line voltage at socket connections #5 and #6. CAUTION: This switch breaks only one side of the line, consequently socket connection #5 is always "alive" with the line voltage. We urge that due safety precautions be observed when connections are made to the accessory socket and relay circuit.

SERVICE AND MAINTENANCE HINTS

WARNING: Voltages dangerous to life are present at practically all points on the chassis. The Heath Company will not be responsible for injuries which could occur while making tests. Do not attempt to make voltage checks or service the transmitter without taking standard precautions and using the proper equipment. If in doubt, secure the assistance of a competent technician.

IMPORTANT: Read list of errors that could possibly damage your transmitter.

General Service

Analyzing and Isolating Difficulties

Power Supply

Oscillator Stage

Buffer Stage

Final Amplifier Stage

Speech Amplifier and Modulator Stages

Grid Drive -- See Oscillator and Buffer Sections

Plate Current -- See Final Amplifier Section and Antenna Considerations.

Meter Circuit

Antenna Considerations and TVI.

Listed below are several of the common mistakes that can permanently damage components in your transmitter. Oftentimes while hunting for a minor difficulty in a particular section of the transmitter with the power on, components in another section may be seriously damaged. For example, a high current will be flowing in the final amplifier tube if the final tuning control is not in resonance while observing grid drive readings with the operation switch in the CW position. Switch to the TUNE position.

1. Don't make voltage checks without proper safety precautions. Voltage checks should be done without any distraction. Children should not be allowed near the equipment. Electric shock can be fatal.
2. Don't turn the transmitter to the CW or PHONE position unless you have first obtained a reasonable grid drive reading on the TUNE position.
3. Don't operate the transmitter without proper crystals installed, or the VFO tuned to the proper frequency. Be sure the CRYSTAL-VFO switch is turned to the proper position.
4. Don't leave the transmitter in operation over 5 minutes, even when testing. The duty cycle of the power transformer is 5 minutes on and 10 minutes off. This, of course, refers to continuous operation and does not apply to CW or PHONE operation. PHONE or CW operation under normal operating conditions will not approach the maximum limit.
5. Don't cover the ventilation holes provided in the cabinet.
6. Don't test the oscillator, buffer or modulator stages with the final amplifier on PHONE or CW position if it is not dipped to resonance as indicated by minimum plate current.

Don't try to read grid current to the final amplifier:

- a. When the key circuit is open.
- b. When the meter switch is in the plate position.
- c. With an improper crystal (the drive control tunes a limited range).
- d. With the CRYSTAL-VFO switch in the wrong position.

ANALYZING AND ISOLATION

The transmitter can be divided into stages. Each stage can then be isolated and worked on individually. In the next section, simple steps will be outlined to test each stage. A Vacuum Tube Voltmeter or Multimeter is necessary to check voltages and resistance. Voltages listed were made with a Heathkit Multi-purpose VTVM (Vacuum Tube Voltmeter). The line voltage was 115 volts AC. The transmitter was set up for crystal controlled 80-meter PHONE operation (key circuit closed) for most checks.

Voltages listed do not necessarily indicate those in your transmitter. Line voltage variation, component tolerance and the presence of RF will cause variations. They should only serve as a basis of comparison. AC filament voltage may read high due to the presence of RF which affects the readings on vacuum tube type voltmeters. A more conclusive check in this case may be obtained with a meter such as the Heathkit Volt-Ohm-Milliammeter.

POWER SUPPLY

TUBE E 5U4GB RECTIFIER

1. Check the rectifier tube E by substitution. Be sure the socket is wired to the correct pin connections.
2. REMOVE THE LINE CORD FROM THE POWER SOURCE. Make certain that the filter capacitors are discharged. Test the filter capacitors and high voltage circuit by measuring the resistance between pin #1 of the 5U4GB rectifier tube E and the chassis. It should read between 40 K Ω and 50 K Ω in all positions of the operation switch. A much lower resistance reading may indicate a short circuit in the B+ circuit, a leaky or shorted filter capacitor, or the ohmmeter leads not polarized properly. The meter polarity should favor the higher readings.
3. Check the operation switch for open contacts, or solder that has run into the contacts.
4. Test the transformer by removing the rectifier tube E and measuring the AC voltages. The voltage between the yellow leads should read approximately 5 volts. The voltage between each red lead and the center tap should be 700 to 800 volts. The center tap is the yellow and red lead. Both filament windings should read approximately 6.3 volts AC. The green leads are filament winding #1 and the white leads are filament winding #2.
5. Inspect the filter capacitors and see that they are polarized properly. If not, they should be replaced if current has been allowed to flow through them for any length of time.

OSCILLATOR STAGE

TUBE D 6CL6 OSCILLATOR:

1. Test the 6CL6 tube D by substitution.
2. Check the crystal switch. Make sure the switch is turned to the proper crystal or VFO position.
3. Test the crystal you are using by substituting other crystals of proper frequency.
4. Test the 1.1 mh RF choke in the cathode circuit for an "open" winding (POWER OFF).
5. Check the 40-meter plate coil for an "open" winding (POWER OFF).
6. Filament voltage should check near 6.3 V AC from pin #4 on socket D to chassis.
7. Plate voltage should read approximately 225 to 275 volts, depending on the adjustment of the drive control. This reading is taken from #1 on terminal strip FF to chassis, in the TUNE position.
8. Screen voltage should read approximately 135 to 165 volts depending on the adjustment of the drive control. This reading is taken from Pin #8 on the 6CL6 socket D to the chassis.

BUFFER STAGE

TUBE C 6CL6 BUFFER:

1. Test the 6CL6 tube C by substitution.
2. DISCONNECT THE LINE CORD. Inspect the rotary switch contacts. Be sure there is no solder on the contacts and that each is making a good electrical connection with the rotor.

an open circuit. This is the power transformer center tap. The white cable wire at KK5 should connect to terminal 4 of the operating switch and through terminal 5 to ground but should not be grounded in the STANDBY position. Check this wiring to be sure it is correct. CAUTION: The following tests are made with power on; use extreme care. With a low impedance load (near 52 ohms) connected, the operation switch in the PHONE position, the meter switch in PLATE position, depress the key momentarily. It should read about 1/2 scale, when not tuned to resonance. If the meter shows little or no indication, check the screen voltage at pin 3 of the 6146 tube with a (VOM) Volt-Ohm-Milliammeter using a DC range of at least 150 volts. The screen should read about 100 volts. If much less than this, trace back through contact 3 of the operation switch, through contact 2 to pin 9 of the 6DE7 tube; all should read near 100 volts. Switch the meter to a higher range, 1500 volts, and check pin 1 of the 6DE7. This should read about 580 volts. If the voltages are missing or very far from normal, using the voltmeter on the 1500 volt scale with the schematic diagram, trace the voltage back to its source at the rectifier pin 1. No voltage at E1 indicates an open power transformer primary, open power transformer center tap outlined in the steps above, defective 5U4GB rectifier tube or a short circuit. The latter would probably have made itself known by now.

Lack of grid drive may be traced back to the oscillator. Turn to the TUNE position, make sure the key circuit is closed, and listen with a receiver for the oscillator. Try different crystals. If no signal is heard, check the plate voltage of the oscillator at pin 6 and screen voltage at pin 8. There should be about 250 volts on the plate and about 150 on the screen in the TUNE position.

If low grid drive is experienced on either the 15-meter or the 20-meter band positions, disconnect the 80-meter (black dot) coil from the band switch, turn it end for end, reform the leads, and solder back in place.

As the two 6CL6 tubes are in series, no voltages on the oscillator may be due to an open circuit or defective 6CL6 in the buffer stage. Consequently, both stages must be operating properly to obtain grid drive. The plate voltage of the buffer stage will be about 580 volts to ground and its cathode should be about 250 volts to ground (in the TUNE position). If the voltages differ greatly, remove the power and completely check the circuit.

In certain rare cases, keying is completely normal in the TUNE position but erratic keying, or no keying at all, occurs in the CW position. This condition is generally corrected by carefully removing exactly 23 turns of wire from the 40-meter slug tuned coil, Part #40-104. Begin at the red dot terminal, which is the outside of the winding. This changes this coil to a 20-meter coil. Use the same procedure as prescribed on page 31, tuning the slug for the first peak in grid current. Sufficient drive should still be obtained on all bands using proper crystals or VFO.

FINAL AMPLIFIER STAGE: The 6146 final tube can be damaged in a few seconds if the final is not tuned to resonance. If you wish to test other stages with the plate current on, switch to the TUNE position. This will enable you to operate the transmitter up to the final amplifier, including the indication of grid current on the panel meter without any RF output. The TUNE position removes the plate and screen voltage from the 6146 and grounds the screen grid, however, use caution as the high voltage is still present in other sections of the transmitter. Failure to obtain a dip in plate current when tuning the final amplifier may be due to a lack of grid drive, incorrectly wired final tank coil, loading capacitor advanced too far (insufficient capacity), shorted coax line, the crystal switch in the wrong position, or with an improper crystal or one out of the tuning range of the buffer stage.

A low impedance antenna system on the 80-meter band will also give the same effect and may even result in the meter being "pinned" at the full scale reading until sufficient capacity has been added in parallel to the 2-gang output loading capacitor. See Final Amplifier section.

NOTE: When using the DX-40 on CW with the VF-1, the VF-1 operation switch should be placed in the STANDBY position, and the key plugged into the DX-40. For best results with either crystal or VFO, the grid drive should be adjusted as near as possible to 3 milliamperes. In some cases and on certain bands, slightly more than the indicated 3 milliamperes will result in added efficiency.

GROUNDING: The importance of a good ground that presents low impedance at all frequencies cannot be emphasized too strongly. What may be a perfectly satisfactory ground at 80 meters could place the transmitter considerably above ground at the higher RF frequencies. As an example, the length of the ground wire is sometimes critical. An 8 foot wire from the transmitter to ground would be a direct short at 80 meters but becomes one-quarter wave length at 10 meters and therefore places the chassis at a high RF potential. Some hints that will be of assistance in obtaining a good ground are:

1. Connection for the ground should be made to cold water or well pipes and/or multiple pipes or rods driven approximately eight or more feet into moist earth. A salt solution poured around the ground rods will further increase the conductivity to ground. A more elaborate installation might include a system of wires approximately one-quarter wave length long laid a few inches under the surface of the earth in a grid or radial pattern. The use of one or all of these grounding systems may be combined to form a good ground reference.
2. The electrical connection to the ground point should consist of a short heavy conductor (#12 wire or heavier, or copper braid). If a short ground wire is difficult to obtain because of transmitter location, several leads of random length may be used. The use of random leads lessens the possibility that all leads should become one-quarter wave length at the frequency of operation. If the transmitter becomes hot with RF at one particular frequency, the addition of a ground wire cut to one-half wave length at this frequency may clear up the difficulty.

Some of the symptoms of inadequate grounding are manifested in the form of:

1. Inability to load the antenna properly.
2. High RF potentials on the chassis or case of the transmitter as well as the microphone and cable.
3. Undue voltage strain on output circuit components.
4. Final plate current reading affected by touching the panel or case.
5. Television or broadcast interference.

LOCATION: The transmitter should be located where free circulation of air is possible and objects should not be placed on the case as this might restrict the circulation of air. Good ventilation is essential to insure maximum component life. The considerations mentioned with regard to grounding will also affect the selection of a good location, as will the point of entry of the antenna feed line.

OPERATION: The tuning procedure outlined previously will also apply when loading an actual antenna. Some special cases involving particular antenna types will require special consideration and will be covered under antennas.

ACCESSORY SOCKET

The octal accessory socket on the rear of the chassis was provided to furnish power for an external VFO such as the Heathkit VF-1. Filament power is obtained from pins 1 and 2 with 1 being ground for operation of an external unit having one side of the filament at ground potential. Pin 4 supplies B+ voltage through a 20 K Ω 10 watt resistor. This provides approximately 250 volts at 20 milliamperes. Pin 8 is connected to the cathode keying circuit and allows an external VFO to be keyed along with the DX-40. Pin 1 is grounded for the filament and the shield cable between the transmitter and the VFO. See Figure 21.

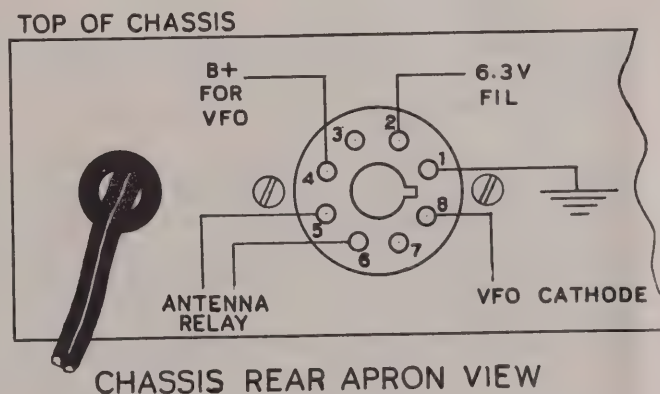


Figure 21

NOTE: Connection points are provided on the Accessory socket for the operation of an antenna relay, to take advantage of the improved receiver performance realized when using the transmitting antenna on the receiver.

Upon obtaining a reading at, or near 3 milliamperes grid current to the final amplifier, switch the meter to read plate current. The operation switch is switched to PHONE position and the final tuning control is tuned to the lowest reading of plate current. This "dip" should occur near #90 on the dial with the bandswitch on 10 meters.

NOTE: These tests were made with a 3500 kc and 7000 kc crystal. The "off-tuned" plate current generally does not exceed 75 milliamperes due to the low screen voltage on the 6146 in the PHONE position without modulation. Once tuned to minimum current in the PHONE position, switch to CW operation. This will show a much higher average plate current, with more pronounced "dips".

To load the antenna or dummy load, always start with the antenna tuning (loading) control closed at "O" position. The final tuning is always tuned to resonance, or minimum plate current. When the loading control is moved, it detunes the output circuit and this has to be compensated for by redipping the final tuning control to resonance. Keeping this in mind, gradually open the antenna tuning to indicate #20 on the dial. Now return to the final tuning control and redip it to minimum current. Increase the loading to approximately 40 on the dial. Redip the final to minimum. Increase the loading still farther and redip the final until the "dip" is at, or near, the recommended "loaded" current which is 125 milliamperes in the CW position.

This successive loading and redipping is recommended for tuning of the pi network output circuit of this transmitter except when using an antenna tuner or coupler, in which case the loading capacitor is left closed at or near the "O" position to provide a low impedance.

It would be more convenient to make the operation of "loading" two handed. Bringing up the loading with the left hand and dipping the final with the right hand in succession until the required plate current is reached. With a little practice "loading" will be no problem. When loaded to the full CW rating, switch to PHONE position and modulate. With sufficient modulation the plate current should kick-up near 125 milliamperes on peaks. If a light bulb is being used as a dummy load it should increase in brilliance in accordance with the voice level. A field strength meter or the "S" meter on the station receiver will also show a definite increase in carrier level.

NOTE: This particular modulation system requires quite heavy antenna loading. Loading to the CW rating and then switching to the PHONE position is customary procedure. It has been noted that with a constant audio tone of sufficient amplitude the RF output can be adjusted to maximum with greater ease. Depending on the voice of the operator, the gain of the microphone, and the amount of antenna loading, an ideal position between the operator and the microphone should be chosen and maintained for proper modulation. Extremely close talking with a high gain microphone should be avoided to prevent clipping of modulation peaks.

In most cases the RF gain control of the receiver has to be reduced and/or the antenna removed or the antenna terminal grounded to the receiver chassis to prevent pinning the "S" meter. With the gain reduced on the receiver to prevent overloading the AVC or causing audio feedback, the speech should sound clear and distinct.

NOTE: There are times when quite heavy loading is obtained with the (antenna tuning) loading capacitor completely closed at "O" position. This will occur especially at the low frequency end of the 80-meter band when working into a low impedance 50 Ω line. When this occurs, additional capacity will be required in parallel with the 2-gang loading capacitor. See Service and Maintenance Hints.

INSTALLATION AND OPERATION

NOTE: It should be noted that an Amateur Radio Operator and Station License is required to place this transmitter on the air. Information regarding licensing and amateur frequency allocations may be had from publications of the Federal Communications Commission or the American Radio Relay League. This transmitter can be used for novice operation only if the following two requirements are met: (a) CW operation only. (b) Crystal control only, on assigned novice frequencies.

NOTE: Due to the action of the polarized electrolytic capacitors the ohmmeter test leads should be interchanged to favor the higher resistance readings.

Again, before applying power, check all solder connections, making sure none have been missed and that all are good electrical connections. Check the coax antenna connector from the center terminal to the outside of the coax for a short. It should check "open". Check the microphone connector in the same manner. It should also check "open".

TUNING INSTRUCTIONS

If any of the following tests cannot be performed or show abnormal indications, turn to the section of the manual entitled Service and Maintenance Hints. Set the transmitter up as follows; crystal switch in any position (no crystals or VFO plugged in); operation switch OFF; drive control in any position; bandswitch 10-11 meter position; antenna tuning "O" position; grid-plate switch in PLATE position; final tuning "O" position.

Plug the line cord into a 117-volt AC receptacle. Nothing should happen, if anything does, pull the line cord immediately. There is trouble in the AC power circuits which must be corrected before proceeding. If operation is normal so far, switch the operation switch to the STANDBY position.

The pilot light and all tubes should light but there should be no meter reading or other indication yet. Switch to PHONE position. With the key plugged in there will now be voltage across the key terminals so use caution. Depress the key momentarily. The meter (switched to PLATE position) should read between 1/2 and full scale. Release the key.

For the following adjustments an 80-meter crystal in the range of 3500 to 3600 or a 40-meter crystal in the range of 7000 to 7200 should be used. A VFO tuned within these limits would also suffice. Install the crystal in any of the three sockets and set the crystal switch for this socket or the VFO position. Set the bandswitch to 10 meters and connect a dummy load such as a 40-watt light bulb from the ground bolt to the center of the coax connector. Switch the meter to read grid current. Set the operation switch to STANDBY and plug the line cord into a power source. Set the loading (antenna tuning) control to "O" (capacitor fully meshed). After about two minutes time for tube warmup, switch to TUNE position, with the meter switched to read grid current, depress the key and adjust the drive control for maximum grid current reading. Release the key.

Locate the 40-meter oscillator coil adjustment on top of the chassis and lubricate it with one drop of light oil. With a radio-TV type alignment tool or a small screwdriver, turn the slug (counter-clockwise) to the end of its travel. Do not try to force it past this point to avoid fracturing the powdered iron core slug.

Close the key and turn the slug (clockwise) until maximum grid current is indicated. Release the key.

NOTE: This indication does not mean that the oscillator plate coil is tuned exactly to the frequency, the fact being that in some cases the oscillator provides more than sufficient drive for the buffer stage, in which case a slight off-tuning of the oscillator coil results in an increased grid current reading to the 6146 final tube.

In general, this tuned coil should be adjusted for the highest reading of grid current near the range of frequencies in which operations are planned. Once adjusted, it can be left alone as long as sufficient grid drive is obtained.

On 10 meters with a 40-meter crystal, a higher reading is obtained with the slug screwed out farther than when an 80-meter crystal is used. In effect, the oscillator is overdriving the buffer with the 40-meter crystal and detuning the oscillator plate circuit reduces the excess drive to the buffer stage.

PRELIMINARY OPERATION CHECKS

Before applying power to the transmitter, examine your wiring very carefully for possible shorts, such as tube pins touching, resistor or capacitor leads contacting each other, or shorting to the tube socket center shield or to the chassis, coil leads shorting to each other or to the bandswitch frame. Also be sure no wire clippings or solder drops are loose in the chassis. Turn it upside down and give it a good shake.

If there are any short circuits, serious damage may result to the tubes and components when power is applied. As an additional check, **WITH THE LINE CORD DISCONNECTED FROM THE POWER SOURCE**, connect an ohmmeter from pin #1 on socket E to ground. It should read approximately 40 K Ω in all positions of the operations switch. A very abnormal reading at this point in the circuit should be completely investigated before applying power.

So that the amateur may be guided in his purchases of crystals for this transmitter it may be best to mention that only 160, 80, or 40 meter crystals be used, with the preference being 80 and 40 meter, the fact being that some additional feedback may be required in the oscillator circuit for certain 160 meter crystals.

Sufficient grid drive to the 6146 final should be obtained from an 80-meter crystal for operation on 80 through 10 meters, while only slightly more efficiency is evident on the higher frequency bands by using a 40-meter crystal.

The tuning range of this transmitter is limited to the 80, 40, 20, 15 and 10 meter bands. Operation on the 160-meter band should not be attempted.

BUFFER: The buffer stage is coupled to the 6146 final amplifier by a Pi network circuit which has a tuning range limited to the amateur bands. This limitation avoids tuning a wrong harmonic which would be amplified by the 6146 stage. This method of coupling helps materially in stabilizing the final amplifier, at the same time attenuating the higher order harmonics. This buffer stage has an independent filament supply to prevent heater-to-cathode breakdown as this cathode is 300 volts potential above the other tubes.

FINAL AMPLIFIER: The plate circuit of the final amplifier is shunt fed with a .425 mh RF choke and is capacity coupled into the Pi network tank circuit. For operation on 80 meters a 68 $\mu\mu\text{f}$ 4 kv fixed capacitor is automatically paralleled with the plate tuning capacitor by means of the bandswitch. A 900 $\mu\mu\text{f}$ variable capacitor is permanently connected across the output of the Pi circuit for antenna loading.

MODULATOR: A 12AX7 tube is used as a high gain two stage resistance coupled speech amplifier. The constants of the entire speech amplifier and driver stages have been carefully chosen for maximum gain at voice frequencies. This allows a higher average level of modulation to be maintained where it will be the most effective. Also, a simple radio frequency filter network has been incorporated in the microphone input circuit to discourage RF from getting in the audio circuit and causing an annoying feedback.

The audio energy from the speech amplifier is coupled to the grid of one triode section of a 6DE7. This tube contains two dissimilar triode sections. One triode section is rated at 1.5 watts dissipation and the other at 7 watts dissipation. The lower rated triode is used as a direct coupled driver, its plate being tied to the control grid of the heavier duty triode which forms the modulator. This second triode is biased sufficiently to limit its conduction and therefore the screen voltage on the final, which results in a low resting carrier.

With modulation the conduction of the heavy duty triode section is varied in accordance with the average voice level. This gives a controlled carrier effect by varying the screen voltage on the 6146 tube, at the same time the audio signal is superimposed on this variable voltage. The net result is to produce a carrier output which increases with the percentage of modulation applied.

POWER SUPPLY: The power supply consists of a transformer-operated full wave rectifier circuit with a choke input filter. Two filter capacitors are operated in series to withstand the voltage involved. Two identical resistors across the filter capacitors serve a dual purpose of equalizing the filter voltage and acting as a bleeder resistor to stabilize the output under varying load conditions. A 5U4GB tube is used as the full wave rectifier. This tube is a heavy-duty version of the regular 5U4G. Some of the tube ratings have been exceeded while others are operated under the maximum permissible. Tests have indicated that by using the heavy duty tube with choke input and a light current load, no difficulty should be encountered.

INTRODUCTION

The Heathkit Transmitter Model DX-40 was designed to permit maximum versatility at a reasonable price. It features up to 75 watts input with three switch-selected crystal positions for the novice operator. It includes controlled carrier phone operation and provision for VFO excitation for the general class ham. It has sufficient output to drive larger transmitters when the station is expanded, yet is small enough for field day operation.

The DX-40 consists of one power supply, three radio frequency stages, and two dual-triode audio stages. Pi network output coupling is used to facilitate antenna matching. The panel controls consists of a key jack, operation switch, band switch, drive control, pilot light, final tuning, meter switch and antenna tuning. The mike connector, crystal switch, output connector, VFO input and auxiliary power socket are located on the rear chassis apron.

The following block diagram and circuit description will give the builder a better understanding of the transmitter. This knowledge is an invaluable aid to construction and as such is well worth reading thoroughly. LETHAL VOLTAGES ARE PRESENT AT MANY POINTS ABOVE AND BELOW THE CHASSIS. CONSEQUENTLY, GREAT CARE MUST BE EXERCISED WHEN ANY TEST OR ADJUSTMENTS ARE MADE.

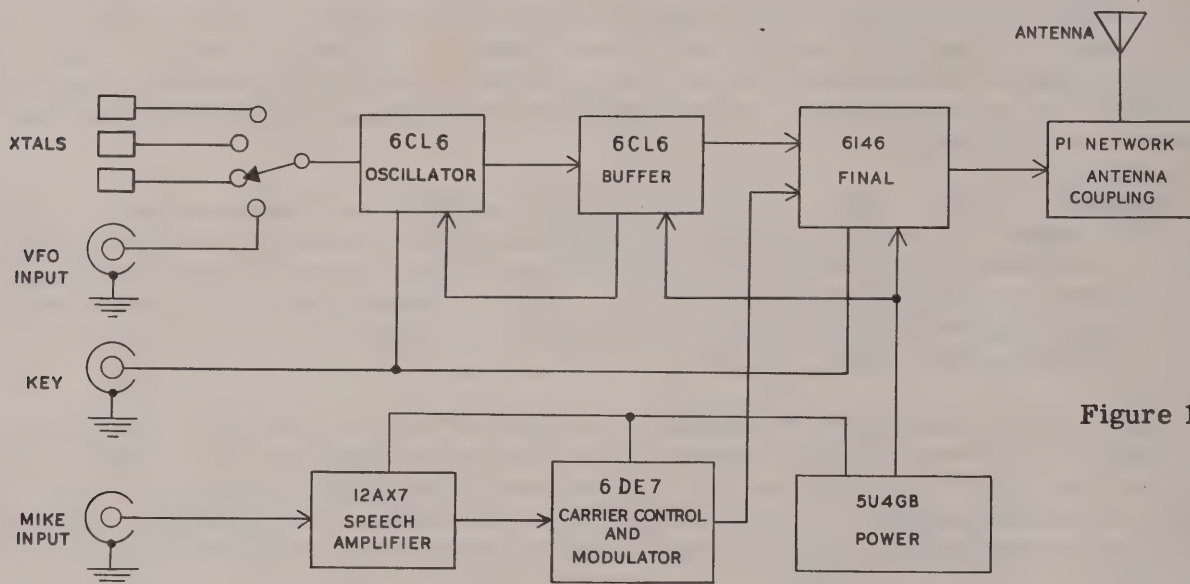


Figure 1

CIRCUIT DESCRIPTION

OSCILLATOR: A 6CL6 tube is operated in a Colpitts circuit to provide efficient harmonic output for use on the high frequency bands. The plate tank circuit consists solely of a slug-tuned coil which is broadly resonant on 40 meters but serves as a radio frequency choke on 80 meters. For operation on 80 through 10 meters the oscillator plate circuit tunes to 40 meters.

Three crystals may be switched into the circuit by means of a double-pole switch which breaks both connections to the crystals to prevent interaction. In the fourth position, the 6CL6 grid is connected to a jack for external VFO control and the cathode RF choke is bypassed to ground.

Plate and screen voltage for the oscillator stage are derived from the buffer stage cathode. The two 6CL6 tubes are operated in series across the 600 volt supply and receive approximately 300 volts each. This eliminates the necessity of power-wasting dropping resistors.

The 6CL6 buffer in most cases, tunes the second, third, or fourth harmonic to obtain the desired frequency. Because the RF level required by the buffer stage is quite low, 80 or 160 meter crystals may be used for output on 80 without the necessity of resonating the oscillator stage plate circuit to these frequencies.

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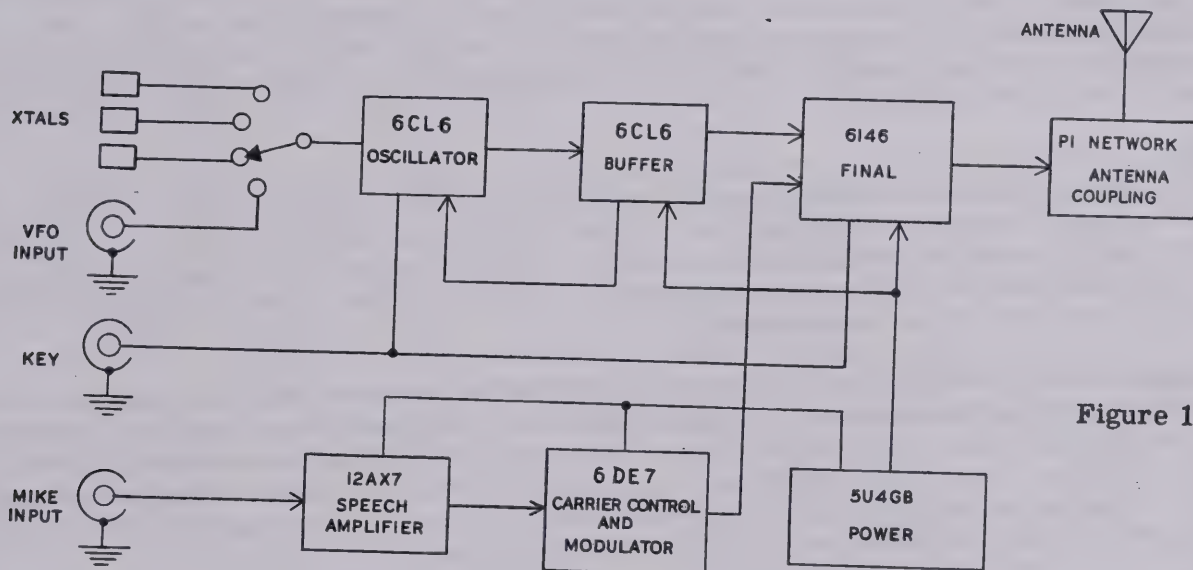


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NOTE: Due to the action of the polarized electrolytic capacitors the ohmmeter test leads should be interchanged to favor the higher resistance readings.

Again, before applying power, check all solder connections, making sure none have been missed and that all are good electrical connections. Check the coax antenna connector from the center terminal to the outside of the coax for a short. It should check "open". Check the microphone connector in the same manner. It should also check "open".

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If any of the following tests cannot be performed or show abnormal indications, turn to the section of the manual entitled Service and Maintenance Hints. Set the transmitter up as follows: crystal switch in any position (no crystals or VFO plugged in); operation switch OFF; drive control in any position; bandswitch 10-11 meter position; antenna tuning "O" position; grid-plate switch in PLATE position; final tuning "O" position.

Plug the line cord into a 117-volt AC receptacle. Nothing should happen, if anything does, pull the line cord immediately. There is trouble in the AC power circuits which must be corrected before proceeding. If operation is normal so far, switch the operation switch to the STANDBY position.

The pilot light and all tubes should light but there should be no meter reading or other indication yet. Switch to PHONE position. With the key plugged in there will now be voltage across the key terminals so use caution. Depress the key momentarily. The meter (switched to PLATE position) should read between 1/2 and full scale. Release the key.

For the following adjustments an 80-meter crystal in the range of 3500 to 3600 or a 40-meter crystal in the range of 7000 to 7200 should be used. A VFO tuned within these limits would also suffice. Install the crystal in any of the three sockets and set the crystal switch for this socket or the VFO position. Set the bandswitch to 10 meters and connect a dummy load such as a 40-watt light bulb from the ground bolt to the center of the coax connector. Switch the meter to read grid current. Set the operation switch to STANDBY and plug the line cord into a power source. Set the loading (antenna tuning) control to "O" (capacitor fully meshed). After about two minutes time for tube warmup, switch to TUNE position, with the meter switched to read grid current, depress the key and adjust the drive control for maximum grid current reading. Release the key.

Locate the 40-meter oscillator coil adjustment on top of the chassis and lubricate it with one drop of light oil. With a radio-TV type alignment tool or a small screwdriver, turn the slug (counter-clockwise) to the end of its travel. Do not try to force it past this point to avoid fracturing the powdered iron core slug.

Close the key and turn the slug (clockwise) until maximum grid current is indicated. Release the key.

NOTE: This indication does not mean that the oscillator plate coil is tuned exactly to the frequency, the fact being that in some cases the oscillator provides more than sufficient drive for the buffer stage, in which case a slight off-tuning of the oscillator coil results in an increased grid current reading to the 6146 final tube.

In general, this tuned coil should be adjusted for the highest reading of grid current near the range of frequencies in which operations are planned. Once adjusted, it can be left alone as long as sufficient grid drive is obtained.

On 10 meters with a 40-meter crystal, a higher reading is obtained with the slug screwed out farther than when an 80-meter crystal is used. In effect, the oscillator is overdriving the buffer with the 40-meter crystal and detuning the oscillator plate circuit reduces the excess drive to the buffer stage.

PRELIMINARY OPERATION CHECKS

Before applying power to the transmitter, examine your wiring very carefully for possible shorts, such as tube pins touching, resistor or capacitor leads contacting each other, or shorting to the tube socket center shield or to the chassis, coil leads shorting to each other or to the bandswitch frame. Also be sure no wire clippings or solder drops are loose in the chassis. Turn it upside down and give it a good shake.

If there are any short circuits, serious damage may result to the tubes and components when power is applied. As an additional check, WITH THE LINE CORD DISCONNECTED FROM THE POWER SOURCE, connect an ohmmeter from pin #1 on socket E to ground. It should read approximately 40 K Ω in all positions of the operations switch. A very abnormal reading at this point in the circuit should be completely investigated before applying power.

Upon obtaining a reading at, or near 3 milliamperes grid current to the final amplifier, switch the meter to read plate current. The operation switch is switched to PHONE position and the final tuning control is tuned to the lowest reading of plate current. This "dip" should occur near #90 on the dial with the bandswitch on 10 meters.

NOTE: These tests were made with a 3500 kc and 7000 kc crystal. The "off-tuned" plate current generally does not exceed 75 milliamperes due to the low screen voltage on the 6146 in the PHONE position without modulation. Once tuned to minimum current in the PHONE position, switch to CW operation. This will show a much higher average plate current, with more pronounced "dips".

To load the antenna or dummy load, always start with the antenna tuning (loading) control closed at "O" position. The final tuning is always tuned to resonance, or minimum plate current. When the loading control is moved, it detunes the output circuit and this has to be compensated for by redipping the final tuning control to resonance. Keeping this in mind, gradually open the antenna tuning to indicate #20 on the dial. Now return to the final tuning control and redip it to minimum current. Increase the loading to approximately 40 on the dial. Redip the final to minimum. Increase the loading still farther and redip the final until the "dip" is at, or near, the recommended "loaded" current which is 125 milliamperes in the CW position.

This successive loading and redipping is recommended for tuning of the pi network output circuit of this transmitter except when using an antenna tuner or coupler, in which case the loading capacitor is left closed at or near the "O" position to provide a low impedance.

It would be more convenient to make the operation of "loading" two handed. Bringing up the loading with the left hand and dipping the final with the right hand in succession until the required plate current is reached. With a little practice "loading" will be no problem. When loaded to the full CW rating, switch to PHONE position and modulate. With sufficient modulation the plate current should kick-up near 125 milliamperes on peaks. If a light bulb is being used as a dummy load it should increase in brilliance in accordance with the voice level. A field strength meter or the "S" meter on the station receiver will also show a definite increase in carrier level.

NOTE: This particular modulation system requires quite heavy antenna loading. Loading to the CW rating and then switching to the PHONE position is customary procedure. It has been noted that with a constant audio tone of sufficient amplitude the RF output can be adjusted to maximum with greater ease. Depending on the voice of the operator, the gain of the microphone, and the amount of antenna loading, an ideal position between the operator and the microphone should be chosen and maintained for proper modulation. Extremely close talking with a high gain microphone should be avoided to prevent clipping of modulation peaks.

In most cases the RF gain control of the receiver has to be reduced and/or the antenna removed or the antenna terminal grounded to the receiver chassis to prevent pinning the "S" meter. With the gain reduced on the receiver to prevent overloading the AVC or causing audio feedback, the speech should sound clear and distinct.

NOTE: There are times when quite heavy loading is obtained with the (antenna tuning) loading capacitor completely closed at "O" position. This will occur especially at the low frequency end of the 80-meter band when working into a low impedance 50 Ω line. When this occurs, additional capacity will be required in parallel with the 2-gang loading capacitor. See Service and Maintenance Hints.

INSTALLATION AND OPERATION

NOTE: It should be noted that an Amateur Radio Operator and Station License is required to place this transmitter on the air. Information regarding licensing and amateur frequency allocations may be had from publications of the Federal Communications Commission or the American Radio Relay League. This transmitter can be used for novice operation only if the following two requirements are met: (a) CW operation only. (b) Crystal control only, on assigned novice frequencies.

GROUNDING: The importance of a good ground that presents low impedance at all frequencies cannot be emphasized too strongly. What may be a perfectly satisfactory ground at 80 meters could place the transmitter considerably above ground at the higher RF frequencies. As an example, the length of the ground wire is sometimes critical. An 8 foot wire from the transmitter to ground would be a direct short at 80 meters but becomes one-quarter wave length at 10 meters and therefore places the chassis at a high RF potential. Some hints that will be of assistance in obtaining a good ground are:

1. Connection for the ground should be made to cold water or well pipes and/or multiple pipes or rods driven approximately eight or more feet into moist earth. A salt solution poured around the ground rods will further increase the conductivity to ground. A more elaborate installation might include a system of wires approximately one-quarter wave length long laid a few inches under the surface of the earth in a grid or radial pattern. The use of one or all of these grounding systems may be combined to form a good ground reference.
2. The electrical connection to the ground point should consist of a short heavy conductor (#12 wire or heavier, or copper braid). If a short ground wire is difficult to obtain because of transmitter location, several leads of random length may be used. The use of random leads lessens the possibility that all leads should become one-quarter wave length at the frequency of operation. If the transmitter becomes hot with RF at one particular frequency, the addition of a ground wire cut to one-half wave length at this frequency may clear up the difficulty.

Some of the symptoms of inadequate grounding are manifested in the form of:

1. Inability to load the antenna properly.
2. High RF potentials on the chassis or case of the transmitter as well as the microphone and cable.
3. Undue voltage strain on output circuit components.
4. Final plate current reading affected by touching the panel or case.
5. Television or broadcast interference.

LOCATION: The transmitter should be located where free circulation of air is possible and objects should not be placed on the case as this might restrict the circulation of air. Good ventilation is essential to insure maximum component life. The considerations mentioned with regard to grounding will also affect the selection of a good location, as will the point of entry of the antenna feed line.

OPERATION: The tuning procedure outlined previously will also apply when loading an actual antenna. Some special cases involving particular antenna types will require special consideration and will be covered under antennas.

ACCESSORY SOCKET

The octal accessory socket on the rear of the chassis was provided to furnish power for an external VFO such as the Heathkit VF-1. Filament power is obtained from pins 1 and 2 with 1 being ground for operation of an external unit having one side of the filament at ground potential. Pin 4 supplies B+ voltage through a 20 K Ω 10 watt resistor. This provides approximately 250 volts at 20 milliamperes. Pin 8 is connected to the cathode keying circuit and allows an external VFO to be keyed along with the DX-40. Pin 1 is grounded for the filament and the shield cable between the transmitter and the VFO. See Figure 21.

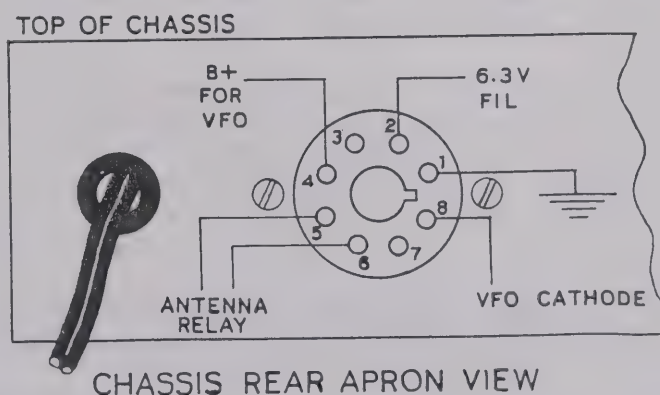


Figure 21

NOTE: Connection points are provided on the Accessory socket for the operation of an antenna relay, to take advantage of the improved receiver performance realized when using the transmitting antenna on the receiver.

Switching the operation switch to either the PHONE or CW position will provide the full line voltage at socket connections #5 and #6. CAUTION: This switch breaks only one side of the line, consequently socket connection #5 is always "alive" with the line voltage. We urge that due safety precautions be observed when connections are made to the accessory socket and relay circuit.

SERVICE AND MAINTENANCE HINTS

WARNING: Voltages dangerous to life are present at practically all points on the chassis. The Heath Company will not be responsible for injuries which could occur while making tests. Do not attempt to make voltage checks or service the transmitter without taking standard precautions and using the proper equipment. If in doubt, secure the assistance of a competent technician.

IMPORTANT: Read list of errors that could possibly damage your transmitter.

General Service

Analyzing and Isolating Difficulties

Power Supply

Oscillator Stage

Buffer Stage

Final Amplifier Stage

Speech Amplifier and Modulator Stages

Grid Drive -- See Oscillator and Buffer Sections

Plate Current -- See Final Amplifier Section and Antenna Considerations.

Meter Circuit

Antenna Considerations and TVI.

Listed below are several of the common mistakes that can permanently damage components in your transmitter. Oftentimes while hunting for a minor difficulty in a particular section of the transmitter with the power on, components in another section may be seriously damaged. For example, a high current will be flowing in the final amplifier tube if the final tuning control is not in resonance while observing grid drive readings with the operation switch in the CW position. Switch to the TUNE position.

1. Don't make voltage checks without proper safety precautions. Voltage checks should be done without any distraction. Children should not be allowed near the equipment. Electric shock can be fatal.
2. Don't turn the transmitter to the CW or PHONE position unless you have first obtained a reasonable grid drive reading on the TUNE position.
3. Don't operate the transmitter without proper crystals installed, or the VFO tuned to the proper frequency. Be sure the CRYSTAL-VFO switch is turned to the proper position.
4. Don't leave the transmitter in operation over 5 minutes, even when testing. The duty cycle of the power transformer is 5 minutes on and 10 minutes off. This, of course, refers to continuous operation and does not apply to CW or PHONE operation. PHONE or CW operation under normal operating conditions will not approach the maximum limit.
5. Don't cover the ventilation holes provided in the cabinet.
6. Don't test the oscillator, buffer or modulator stages with the final amplifier on PHONE or CW position if it is not dipped to resonance as indicated by minimum plate current.

Don't try to read grid current to the final amplifier:

- a. When the key circuit is open.
- b. When the meter switch is in the plate position.
- c. With an improper crystal (the drive control tunes a limited range).
- d. With the CRYSTAL-VFO switch in the wrong position.

GENERAL SERVICE

SOLDERING: Cold and loose solder connections are a common source of trouble in assembling any piece of electronic equipment. Sometimes apparently good solder connections will have an insulating coating of rosin between the wire, the terminal and the solder. This type of defective soldering is very difficult to locate in the process of trouble-shooting, and the builder will do well to see that each wire in a connection point is firmly embedded in the solder. Many times when more than one wire is connected to a terminal or lug the lower wire will not receive sufficient heat or solder even though the connection looks satisfactory. Trouble can also be caused by being too generous with solder and heat, with a short resulting from solder running down the lug and touching the chassis or other components. Use extreme care when soldering to switch contact points, to avoid solder running too far and spoiling the spring tension of the contacts.

With miniature tube sockets there is a possibility of shorts between adjacent socket terminals due to the close spacing. This should be checked and if any doubt exists, the terminals should be pried apart until obvious spacing can be seen between them.

In general, do not rely on the solder itself to form the electrical connection. A firm metal to metal contact should be made before flowing the solder over it.

COMPONENTS: Any part that physically looks defective should be tested with the proper instrument.

TUBES: Tubes can be checked on a tube checker but the best method is by substitution. An extra set of tubes should be on hand for testing and to replace normal tube failures.

WIRING: Mistakes in wiring are the most common cause of difficulty. Consequently, the first step is to recheck all wiring against the pictorials and schematic diagrams. Often having a friend check the wiring will locate an error consistently overlooked.

Follow the construction manual and pictorials so that each lead is placed in its proper position. Make leads as short as possible, except where leads are measured or specifically routed around the edge of the chassis. This is to prevent adverse effects such as spurious RF oscillations and audio feedback.

CAUSE AND EFFECT: Be sure to reread the circuit description on page 3 so that "cause and effect" reasoning may be employed as the search for trouble progresses. If some difficulty still persists after the steps outlined have been completed, attempt to localize the trouble to a particular stage in the transmitter circuit. Use the tuning procedure as a basis for localization and refer to the block diagram and schematic to visualize circuit relationships. The panel meter and station receiver are valuable tools to use in locating trouble.

TRACING PROCEDURE: For the following tracing procedures, use the schematic diagram for reference.

If any activity is noted when the line cord is plugged in and the operation switch is in the OFF position the AC circuit should be traced. One side of the line cord is connected through a line choke to one side of the primary of the power transformer. The other side of the line cord is connected through a line choke to the blue cable wire which connects to terminal 11 of the operation switch; the black cable wire returns from switch terminal 12, to the other primary side of the transformer. Contacts 11 and 12, of the switch thus control line power to the transformer. Also check the four .001 μ f 1400 volt disc ceramic capacitors connected across the line for shorts.

If the tubes and pilot light do not light up when the operation switch is set to STANDBY position, again check the AC circuit with the line cord unplugged to determine why the transformer is not receiving power. If the tubes do light up with the power on and the meter reads in PLATE position, or some other indication of high voltage being applied is apparent, check the following. Unplug the line cord, then with an ohmmeter, check from #5 on KK to ground. It should read

an open circuit. This is the power transformer center tap. The white cable wire at KK5 should connect to terminal 4 of the operating switch and through terminal 5 to ground but should not be grounded in the STANDBY position. Check this wiring to be sure it is correct. CAUTION: The following tests are made with power on; use extreme care. With a low impedance load (near 52 ohms) connected, the operation switch in the PHONE position, the meter switch in PLATE position, depress the key momentarily. It should read about 1/2 scale, when not tuned to resonance. If the meter shows little or no indication, check the screen voltage at pin 3 of the 6146 tube with a (VOM) Volt-Ohm-Milliammeter using a DC range of at least 150 volts. The screen should read about 100 volts. If much less than this, trace back through contact 3 of the operation switch, through contact 2 to pin 9 of the 6DE7 tube; all should read near 100 volts. Switch the meter to a higher range, 1500 volts, and check pin 1 of the 6DE7. This should read about 580 volts. If the voltages are missing or very far from normal, using the voltmeter on the 1500 volt scale with the schematic diagram, trace the voltage back to its source at the rectifier pin 1. No voltage at E1 indicates an open power transformer primary, open power transformer center tap outlined in the steps above, defective 5U4GB rectifier tube or a short circuit. The latter would probably have made itself known by now.

Lack of grid drive may be traced back to the oscillator. Turn to the TUNE position, make sure the key circuit is closed, and listen with a receiver for the oscillator. Try different crystals. If no signal is heard, check the plate voltage of the oscillator at pin 6 and screen voltage at pin 8. There should be about 250 volts on the plate and about 150 on the screen in the TUNE position.

If low grid drive is experienced on either the 15-meter or the 20-meter band positions, disconnect the 80-meter (black dot) coil from the band switch, turn it end for end, reform the leads, and solder back in place.

As the two 6CL6 tubes are in series, no voltages on the oscillator may be due to an open circuit or defective 6CL6 in the buffer stage. Consequently, both stages must be operating properly to obtain grid drive. The plate voltage of the buffer stage will be about 580 volts to ground and its cathode should be about 250 volts to ground (in the TUNE position). If the voltages differ greatly, remove the power and completely check the circuit.

In certain rare cases, keying is completely normal in the TUNE position but erratic keying, or no keying at all, occurs in the CW position. This condition is generally corrected by carefully removing exactly 23 turns of wire from the 40-meter slug tuned coil, Part #40-104. Begin at the red dot terminal, which is the outside of the winding. This changes this coil to a 20-meter coil. Use the same procedure as prescribed on page 31, tuning the slug for the first peak in grid current. Sufficient drive should still be obtained on all bands using proper crystals or VFO.

FINAL AMPLIFIER STAGE: The 6146 final tube can be damaged in a few seconds if the final is not tuned to resonance. If you wish to test other stages with the plate current on, switch to the TUNE position. This will enable you to operate the transmitter up to the final amplifier, including the indication of grid current on the panel meter without any RF output. The TUNE position removes the plate and screen voltage from the 6146 and grounds the screen grid, however, use caution as the high voltage is still present in other sections of the transmitter. Failure to obtain a dip in plate current when tuning the final amplifier may be due to a lack of grid drive, incorrectly wired final tank coil, loading capacitor advanced too far (insufficient capacity), shorted coax line, the crystal switch in the wrong position, or with an improper crystal or one out of the tuning range of the buffer stage.

A low impedance antenna system on the 80-meter band will also give the same effect and may even result in the meter being "pinned" at the full scale reading until sufficient capacity has been added in parallel to the 2-gang output loading capacitor. See Final Amplifier section.

NOTE: When using the DX-40 on CW with the VF-1, the VF-1 operation switch should be placed in the STANDBY position, and the key plugged into the DX-40. For best results with either crystal or VFO, the grid drive should be adjusted as near as possible to 3 milliamperes. In some cases and on certain bands, slightly more than the indicated 3 milliamperes will result in added efficiency.

ANALYZING AND ISOLATION

The transmitter can be divided into stages. Each stage can then be isolated and worked on individually. In the next section, simple steps will be outlined to test each stage. A Vacuum Tube Voltmeter or Multimeter is necessary to check voltages and resistance. Voltages listed were made with a Heathkit Multi-purpose VTVM (Vacuum Tube Voltmeter). The line voltage was 115 volts AC. The transmitter was set up for crystal controlled 80-meter PHONE operation (key circuit closed) for most checks.

Voltages listed do not necessarily indicate those in your transmitter. Line voltage variation, component tolerance and the presence of RF will cause variations. They should only serve as a basis of comparison. AC filament voltage may read high due to the presence of RF which affects the readings on vacuum tube type voltmeters. A more conclusive check in this case may be obtained with a meter such as the Heathkit Volt-Ohm-Milliammeter.

POWER SUPPLY

TUBE E 5U4GB RECTIFIER

1. Check the rectifier tube E by substitution. Be sure the socket is wired to the correct pin connections.
2. REMOVE THE LINE CORD FROM THE POWER SOURCE. Make certain that the filter capacitors are discharged. Test the filter capacitors and high voltage circuit by measuring the resistance between pin #1 of the 5U4GB rectifier tube E and the chassis. It should read between 40 K Ω and 50 K Ω in all positions of the operation switch. A much lower resistance reading may indicate a short circuit in the B+ circuit, a leaky or shorted filter capacitor, or the ohmmeter leads not polarized properly. The meter polarity should favor the higher readings.
3. Check the operation switch for open contacts, or solder that has run into the contacts.
4. Test the transformer by removing the rectifier tube E and measuring the AC voltages. The voltage between the yellow leads should read approximately 5 volts. The voltage between each red lead and the center tap should be 700 to 800 volts. The center tap is the yellow and red lead. Both filament windings should read approximately 6.3 volts AC. The green leads are filament winding #1 and the white leads are filament winding #2.
5. Inspect the filter capacitors and see that they are polarized properly. If not, they should be replaced if current has been allowed to flow through them for any length of time.

OSCILLATOR STAGE

TUBE D 6CL6 OSCILLATOR:

1. Test the 6CL6 tube D by substitution.
2. Check the crystal switch. Make sure the switch is turned to the proper crystal or VFO position.
3. Test the crystal you are using by substituting other crystals of proper frequency.
4. Test the 1.1 mh RF choke in the cathode circuit for an "open" winding (POWER OFF).
5. Check the 40-meter plate coil for an "open" winding (POWER OFF).
6. Filament voltage should check near 6.3 V AC from pin #4 on socket D to chassis.
7. Plate voltage should read approximately 225 to 275 volts, depending on the adjustment of the drive control. This reading is taken from #1 on terminal strip FF to chassis, in the TUNE position.
8. Screen voltage should read approximately 135 to 165 volts depending on the adjustment of the drive control. This reading is taken from Pin #8 on the 6CL6 socket D to the chassis.

BUFFER STAGE

TUBE C 6CL6 BUFFER:

1. Test the 6CL6 tube C by substitution.
2. DISCONNECT THE LINE CORD. Inspect the rotary switch contacts. Be sure there is no solder on the contacts and that each is making a good electrical connection with the rotor.

3. If little or no grid drive is available, there is the possibility that the small buffer coils have been interchanged. A rough check can be made by noting the size of the wire and apparent number of turns. Fine wire and more turns are used on the low frequency coils, with progressively larger wire and lesser turns as 10 meters is approached. Check each coil for a broken winding which would check "open" on an ohmmeter. Also, be sure the coil leads do not short to each other or to the switch frame.
4. WITH ALL POWER REMOVED, test the 1.1 mh RF choke which is connected in the plate circuit for an open winding.
5. With the line cord plugged in, high voltage will be indicated on all pins except 4 and 5 (if measurements are taken from the chassis). This is due to the buffer stage being operated in series with the oscillator stage. Voltage readings on the buffer stage should be taken from the tube cathode which is tied to lug #1 on terminal strip FF. CAUTION: Both meter leads will therefore be "alive". Plate voltage read from lug #1 on terminal strip GG should be approximately 350 to 400 volts (TUNE position), depending on the adjustment of the drive control. Screen voltage should be about 230 volts, also depending on the adjustment of the drive control. Approximately 6.3 volts AC should be indicated between filament pins 4 and 5 on socket D.

FINAL AMPLIFIER

TUBE F 6146

1. Test the 6146 tube G by substitution.
2. Grid drive should be approximately 3 ma. for proper operation.
3. WITH THE LINE CORD DISCONNECTED, check the .425 mh RF choke in the final plate circuit with an ohmmeter.
4. Tighten the nuts on the feedthrough insulators (top and bottom).
5. Inspect the antenna tuning condenser and the final amplifier condenser for shorts, such as solder drips from capacitor terminals shorting to the chassis.
6. Check the 68 $\mu\mu\text{f}$ capacitor between the bandswitch terminal A8 and the grounded lug on the terminal strip. A swollen capacitor will indicate that the component has been damaged by excessive RF current due to trying to load an improper antenna impedance. The swelling of the capacitor will have decreased in its capacity and it will require replacement. This capacitor is only used in the circuit on the 80-meter band.
7. Inspect the connections of the final tank coil to the bandswitch. Make sure each is connected to the proper terminal on the switch.

GRID DRIVE to the final amplifier stage is essential to supply safe operating bias to the 6146. The final amplifier should not be on for more than a few seconds if no grid drive is indicated on the panel meter.

THE DRIVE CONTROL tunes only the upper and lower extremes of the band, no (outside) harmonics.

KEYING is accomplished by grounding the cathode of the Final Amplifier and the Oscillator stage. Poor solder connections in this circuit can cause erratic keying.

DIPPING the final is accomplished by tuning the stage to resonance or to minimum plate current indication. The antenna tuning or loading capacitor should be closed at "O" position before beginning to load an antenna. Dip the final to read minimum plate current, open the loading capacitor a little at a time, successively redipping the final until the final "dip" is at the recommended current value. If the dip is too low on the plate meter and it is impossible to load it with the

Antenna Tuning Condenser, the antenna impedance is not proper and should be checked. This is also true if it will not dip at all. The easiest test for this condition is to substitute a dummy load, (a 115 volt, 60-watt bulb) for the antenna.

NOTE: Feeding a very low impedance antenna, especially at the low frequency end of the 80-meter band may require additional capacity, such as a .001 μf (large size mica) connected across the coax output connector to allow a proper "dip" in plate current. This may be done with a coax "T" connector if required. CAUTION: Remove this capacitor before attempting operation on any other band as it will make it impossible to "load" the antenna.

CREEPING PLATE CURRENT will usually indicate a "soft" 6146 final amplifier tube. Loss of grid drive usually accompanies this condition. This is usually caused by consistent operation of the 6146 tube in an overloaded condition. Plate voltage reading will be the total B+ voltage which can be read at Pin #1 on the 5U4GB rectifier socket E and should be near 600 volts. Once again, use caution in testing high voltages. The screen voltage (with no modulation) should be about 100 volts.

SPEECH AMPLIFIER AND MODULATOR STAGES

TUBE A -- 12AX7 Dual Triode

TUBE B -- 6DE7 Dual Dissimilar Triode

1. Test the 12AX7 tube A, and the 6DE7 tube B, by substitution.
2. With the line cord disconnected, test the resistance between the ungrounded end of the .1 μf paper capacitor (lug #1 on terminal strip BB) and the chassis. It should read approximately 500 K Ω on the OFF and PHONE positions. The other switch positions should show no readings.
3. Inspect all pin connections on the tube sockets for poor solder connections.
4. Recheck the step-by-step wiring and be sure that components and leads are connected to the correct numbered pin connections on the sockets.
5. With a crystal plugged in, the power on and the transmitter tuned for CW conditions, switch to PHONE position. Measure the voltage from lug #1 on terminal strip BB to the chassis. It should read approximately 230 volts, as read on a Heathkit VTVM. The plate voltage on the first triode section of the 12AX7, read from pin #6 to the chassis with the VTVM, should be about 70 volts on the 150 volt scale, and the grid voltage near -.6 volts on the 1.5 volt scale, read from pin #7 to the chassis. The second triode plate, from pin #1 to chassis, should read about 90 volts. The first triode cathode is grounded. Voltage reading on the 12AX7 second triode cathode should be about .9 volts, measured across the 2.7 K Ω resistor, from pin #3 to the chassis.
6. Plate voltage on the 7 watt triode section of the 6DE7 should be approximately 580 volts. This is read from pin #1 of the 6DE7 to the chassis. This same voltage read from plate to cathode (pins #1 to #9) is about 460 volts. The plate voltage of the 1.5 watt driver triode is near 20 volts (with no modulation), read on the 50 volt scale of the VTVM, from pin #6 to chassis. The first triode cathode is grounded. Screen voltage for the 6146 final amplifier is obtained (through the 10 K Ω resistor) from the heavy duty triode section cathode, which is pin #9. The voltage at pin #9 to chassis is approximately 115 volts and at the 6146 screen grid pin #3 is near 100 volts with no modulation. The grid voltage read from pin #7 to chassis, with the VTVM, should be near -.9 volts.

METER CIRCUIT: A 100 Ω one milliampere D'Arsonval movement meter is switched to read plate or grid current to the 6146 final amplifier tube. To avoid extreme excursions of the meter pointer while operation on CW, it may be advisable to leave it switched to the lower reading grid position.

The meter shield can serves to mount the meter as well as shielding any RF radiation through the meter hole which could cause TVI.

THE ANTENNA

NOTE: How important a part the antenna plays in attaining the final result required of a transmitter cannot be stressed too strongly. Any additional effort spent to obtain an "ideal" antenna will more than pay for itself in making possible many satisfactory "over the air" contacts.

The pi network output circuit of the Model DX-40 will match pure resistive loads from approximately 50 to 1000 Ω , and will eliminate the need for an antenna coupler when used with nominal impedance feed lines. The transmitter will match antennas and unbalanced lines within these limits provided such antennas or lines are nonreactive. Reactive antennas or lines present a somewhat different problem since the reactance takes the form of impedance which may raise or lower the antenna impedance beyond the matching range of the transmitter output circuit. It is possible to load a high impedance line, but it is preferable to use a low impedance feed line which will reduce the voltage and radiation from the feeders. Feeding a doublet antenna with 72 Ω coax is an example of a low impedance match, when used on the band for which it is cut.

Attempting to load the transmitter to an improper antenna will cause high percentages of reflected power to flow in the final tank circuit. This may damage the components in the final stage. Usually, a mismatched antenna will also be more conducive to television interference and the amateur may be well advised in the case of persistent TVI to experiment with various antennas and feed lines. Also a loose contact or any shorting in the antenna system will cause interference.

Balanced antenna systems should be fed through an antenna coupler so that neither leg of the line nor the antenna will be at ground potential. Normally the output of the transmitter is unbalanced since one side of the output circuit is grounded.

When loading to either a balanced or an unbalanced system, the maximum loading point of 125 milliamperes in the final stage should not be exceeded. In many instances, the transmitter will load to a higher level, but the harmonic suppression of the pi network is better if the output coupling capacitor is not reduced to absolute minimum value. Then too, the extra 5 or 10 watts which would be gained by maximum loading would not make any detectable difference at the receiving end of the transmission.

END FED HERTZ AND MARCONI ANTENNAS

This type of antenna consists merely of a single wire from one-fourth wave length long to any even multiple thereof. One end of the wire is coupled to the transmitter and the other end supported in space. If this antenna is operated against ground, it is known as a Marconi antenna, while if the length is one-half wave length or more, it is known as a Hertz antenna. The greatest disadvantage of feeding a single wire is the necessity of bringing part of the radiating element into the radio room where its proximity to nearby objects increases losses. The greatest advantage of such an antenna is the simplicity with which it may be constructed and its compact size where space is at a premium. Providing the reactance of such antennas is not excessive they may be loaded satisfactorily with the pi network output circuit of the DX-40.

The length of such antennas can be calculated from the information given in the Radio Handbook or the ARRL Antenna Manual. Random lengths may also be used effectively except for some critical antenna lengths where the antenna impedance becomes too high or too low to be matched satisfactorily at the output of the transmitter. When such a situation is encountered it can usually be recognized by the action of the loading control on the transmitter. Should it be found that increasing the loading (reducing the antenna tuning capacitor value) does not raise the final amplifier plate current reading on the meter and yet the final amplifier has not become fully loaded, it is very likely that the antenna being used has a higher than normal reactance at the frequency of operation, resulting in the transmitter looking into a higher overall impedance.

If it is found that a change in the antenna tuning capacitor value has little effect on the final amplifier loading and does not affect the final amplifier tuning in the normal fashion, the antenna in use is probably presenting lower than normal impedance to the transmitter.

BALANCED ANTENNA FEEDERS AND SYSTEMS

In the average station it will be found expedient to have the radiating portion of the antenna some distance from the transmitter. This statement assumes that the amateur will have his antenna up high and clear of nearby objects, whereas the actual transmitter may be in the basement or any other room in the home. In such a case, some form of transmission line must be used to efficiently connect the transmitter to the antenna. In many instances, the transmission line is of the "balanced" type in which neither leg of the line is grounded. Such transmission lines may be either tuned or untuned, but in either case, a balanced line must be fed through an antenna coupler or "balun" coils. The coupler also provides the means for matching the impedance of the antenna, which will vary depending upon the type of antenna employed. A typical antenna coupler circuit is shown in Figure 22.

Basically the antenna coupler is an impedance transformer, transforming the impedance of the transmitter to the impedance of the transmission line.

Referring to Figure 22, coil L1 should match the impedance of the coaxial cable as closely as possible at the frequency of operation. The circuit consisting of L2, C1 and C2 must tune to the transmitter frequency. If it is desired to series tune the antenna, the shorting bar between 3 and 4 is opened and the transmission line connected at these points. For parallel tuning, 3 is shorted to 4 and the transmission line connected to 1 and 2. Taps are provided on coil L2 to facilitate matching the transmission line.

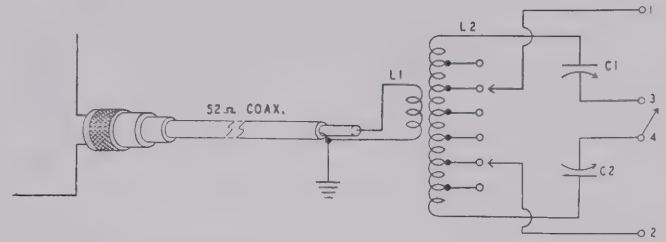


Figure 22

Such a unit can be built up from this or other suggested circuits or may be purchased commercially as a completed unit. In any case, feeding folded dipoles, end-fed "Zepps" and similar antenna types will require an antenna coupler or balun coils since the normal output of the DX-40 is designed for single-ended, unbalanced operation.

There are countless variables which affect the proper operation of an antenna. For example, one leg or section, or the entire antenna may be in close proximity to a large metal body such as a metal covered roof, the steel framework of buildings, eavestroughs, pipes, and other wires, etc. This would cause an unbalance and more difficult loading and have the result of absorbing a good deal of the radiated RF energy which would limit the transmitter's ability to "get out".

The Heath Company would rather not make recommendations as to the kind of antenna you should use. There are many that will work and each has its own characteristics. In general, a tuned antenna fed with untuned feeders can be connected directly to the transmitter. The antenna should be cut to one-half wave length for the frequency and fed in the center with 72Ω coax.

A Folded Dipole type of antenna can be used if it is cut to one-half wave length at the operating frequency and fed with balanced lines. However, Balun coils should be used such as the Heath-kit Balun Coil Set.

The long wire type of antenna is considered high impedance when end fed. For best results, it should be equal to one-half wave length at the lowest operating frequency and connected to the transmitter through a suitable antenna coupler.

Certain types of off-center fed antennas are not recommended for use with the DX-40 without the proper use of Baluns.

Harmonic radiation or TVI in some cases has been traced to an improper antenna or an incorrectly loaded antenna. Be sure your final stage tuning is dipped to the proper point of resonance. A strong second harmonic can usually be corrected by the use of an antenna that is not resonant to the second harmonic. A Folded Dipole antenna cut to one-half wave length at the operating frequency and fed through Balun Coils will usually correct this condition.

Needless to say, no attempt has been made here to cover the theory of antennas, as such, since much has been written on this subject. The possibilities in different antenna types and different feed systems are many and the factors mentioned herein only scratch the surface of the subject. Each operator will need to do his own investigation into the advantages and disadvantages of the various systems to determine just which one will best suit his needs. Basic data is available through the Radio Amateur Handbooks and other technical publications.

Some formulas that should prove helpful are listed as follows:

$$1 \text{ wave length in space} = \frac{300,000 \text{ meters}}{F_{kc}}$$

$$\text{Center fed dipole one-half wave long (length in feet)} = \frac{468}{F_{mc}}$$

$$\text{Folded dipole one-half wave long (length in feet)} = \frac{462}{F_{mc}}$$

$$\text{Zepp antenna one-half wave long (length in feet)} = \frac{492}{F_{mc}}$$

LOW PASS FILTERS: The harmonic rejection of the pi network output circuit of the DX-40 is excellent and will attenuate harmonics considerably when the transmitter is properly grounded and carefully tuned. However, additional harmonic attenuation may be had with the use of a low-pass filter between the output of the transmitter and the feed line or antenna. Such a filter should be designed to handle the maximum power output of the transmitter and must be operated into its nominal impedance.

An instrument to determine standing wave ratio on the feed line is a necessity in every ham shack. The HEATHKIT® Reflected Power Meter serves this purpose, and may be left permanently connected in the feed line of any amateur transmitter.

While the above instrument is preferred, the HEATHKIT® Power Meter will indicate maximum power output when tuning the transmitter. It will not indicate standing wave ratio, and is recommended only as a tuning aid.

Additional information on antennas can be found in:

Radio Amateurs Handbook - ARRL

The Antenna Handbook - ARRL

The Radio Handbook - Editors and Engineers, Ltd.

The Antenna Manual - Editors and Engineers, Ltd.

The Beam Antenna Handbook - Radio Publications

PART No.	PARTS Per Kit	DESCRIPTION
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Resistors

1-1	2	47Ω 1/2 watt
1-9	1	1000Ω 1/2 watt
1-10B	1	47 KΩ 2 watt
1-13	1	2700Ω 1/2 watt
1-16	1	4700Ω 1/2 watt
1-26	2	100 KΩ 1/2 watt
1-33	3	470 KΩ 1/2 watt
1-35	3	1 megohm 1/2 watt
1-37	1	2.2 megohm 1/2 watt
1-40	1	10 megohm 1/2 watt
1-46A	3	27 KΩ 1 watt
1B-15	1	1000Ω 2 watt
2-127	1	.67Ω 1% precision
2-128	1	20Ω 1% precision
3E-2	1	10 KΩ 5 watt
3J-8	1	15 KΩ 10 watt
3J-9	2	20 KΩ 10 watt

Capacitors

20-1	2	47 μmf silver mica
20-32	1	100 μmf 1000 V
20-39	1	220 μmf silver mica
20-41	1	22 μmf silver mica
20-48	1	.001 μmf 2 kv mica
20-61	1	27 μmf mica
21-9	1	100 μmf disc ceramic
21-13	1	500 μmf disc ceramic
21-31	3	.02 μf disc ceramic
21-35	1	.005 μf 1.6 kv disc ceramic
21-43	4	.001 μf 1 kv disc ceramic
21-49	1	68 μmf 4 kv disc ceramic
21-52	22	.002 μf 1 kv disc ceramic
21-71	4	.001 μf GMV 1400 V
23-11	1	.1 μf 600 V paper
23-15	1	.5 μf 400 V paper
25-36	2	40 μf 450 V electrolytic
26-9	1	450 μmf variable (dual)
26-24	1	20 μmf variable
26-31	1	140 μmf variable

Coils-Chokes-Transformers

40-86	1	Amplifier plate coil
40-104	1	40 meter oscillator coil
40-105	1	80 meter buffer coil
40-106	1	40 meter buffer coil
40-107	1	20 meter buffer coil
40-108	1	15 meter buffer coil
40-109	1	10 meter buffer coil
45-4	2	1.1 mh RF choke
45-19	1	Parasitic choke
45-28	2	Line choke
45-41	1	.425 mh RF choke
46-12	1	7 henry 150 ma filter choke
54-38	1	Power transformer

PART No.	PARTS Per Kit	DESCRIPTION
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Switches-Meters-Tubes

60-2	1	DPDT slide switch
63-115	1	Crystal switch
63-139	1	Operations switch
63-140	1	Bandswitch
407-46	1	1 milliampere meter
411-2	1	5U4GB tube
411-26	1	12AX7 tube
411-63	2	6CL6 tube
411-75	1	6146 tube
411-109	1	6DE7 tube
412-1	1	#47 pilot light
413-2	1	Pilot light jewel

Terminal Strips-Sockets-Knobs

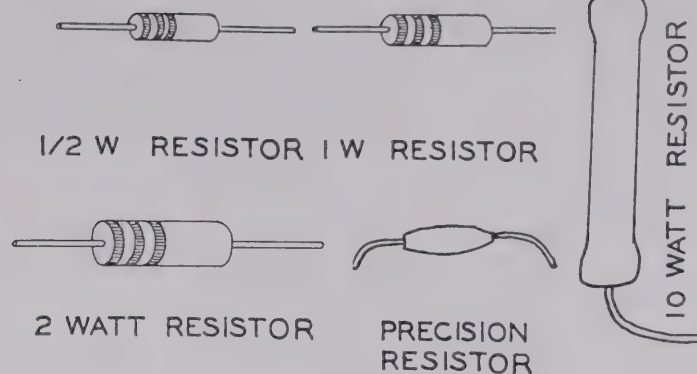
431-2	3	2 lug terminal strip
431-3	1	3 lug terminal strip
431-10	4	3 lug terminal strip
431-11	1	5 lug terminal strip
431-12	2	4 lug terminal strip
431-15	1	1 lug terminal strip
431-16	3	2 lug terminal strip
431-26	1	1 lug terminal strip
432-3	1	Microphone connector
434-21	1	Pilot light socket
434-38	3	Crystal socket
434-39	3	Octal socket
434-42	1	Phono socket
434-43	1	9 pin shield socket
434-56	2	9 pin socket
434-75	1	9 pin (ceramic) socket
436-4	1	Phone jack
436-5	1	Coaxial jack
100-M54	2	Pointer knob, large
462-19	3	Gray knob, small
462-36	1	Red knob, small

Miscellaneous

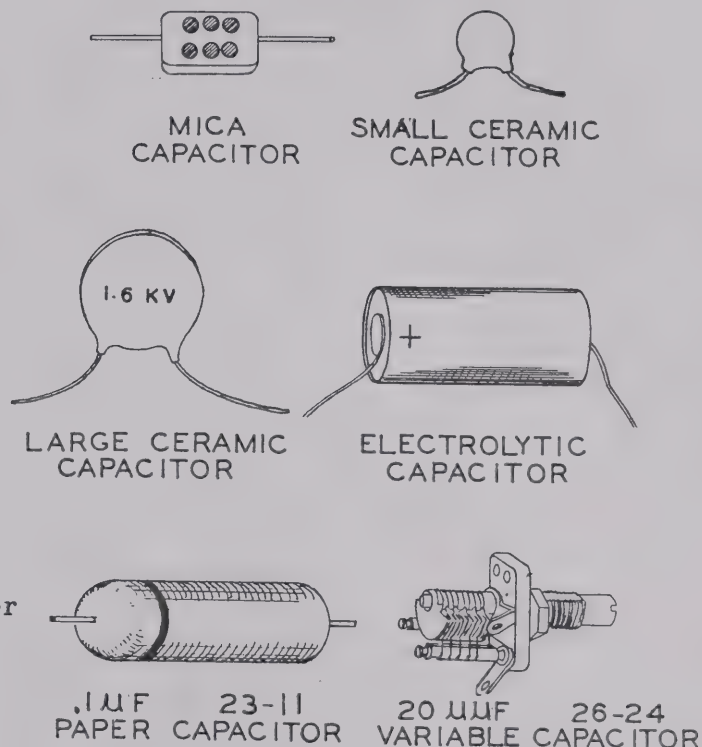
71-2	2	Feedthrough insulator
73-1	2	3/8" Rubber grommet
73-3	1	1/2" Rubber grommet
73-4	5	5/16 Rubber grommet
89-1	1	Line cord
100-105	1	Cable assembly
260-10	1	Ceramic plate cap
261-6	4	Rubber feet
340-1	1	Length #14 tinned wire
340-2	1	Length #20 tinned wire
340-3	1	Length #16 tinned wire
343-2	1	Length coaxial cable
343-3	1	Length shield wire
344-1	3	Lengths hookup wire (gray, green, yellow)
346-1	1	Length sleeving
391-3	1	Logotype (silver)
453-22	1	Shaft extention
595-180	1	Instruction manual

No.	Per Kit	
Metal Parts		
90-68	1	Cabinet
200M136	1	Chassis
203-133-F171	1	Front panel
204-M137	1	Shield bracket
204-M138	1	Switch support
206-3	1	Tube shield
206-43	1	Coaxial shield
206-54	1	Tube shield 2 3/8"
206-55	1	Tube shield base
206-56	1	Meter shield
206-M59	1	Shield Plate
Hardware		
250-4	4	4-40 3/8 RHMS
250-8	11	#6 sheet metal screw
250-9	9	6-32 x 3/8 RHMS
250-18	13	8-32 x 3/8 RHMS
250-31	22	6-32 x 1/4 RHMS
250-33	1	#6 1/8" set screw
250-34	3	4-40 x 1/2" RHMS
250-48	2	6-32 x 1/2" RHMS
250-49	8	3-48 x 1/4 BHMS
250-54	1	10-32 x 5/8 RHMS
251-1	3	6-32 spade bolt
252-1	8	3-48 nut
252-2	4	4-40 nut
252-3	29	6-32 nut
252-4	13	8-32 nut
252-5	2	#10-32 nut
252-7	5	3/8-32 control nut
252-15	3	4-40 x 3/16 nut
253-1	1	#6 fiber flat washer
253-3	2	#10 fiber flat washer
253-7	2	#10 fiber shoulder washer
253-10	5	3/8 flat washer
254-1	33	#6 lockwasher
254-2	18	#8 lockwasher
254-3	1	#10 lockwasher
254-4	4	3/8" lockwasher
254-7	8	#3 lockwasher
255-13	2	#6 1/4" spacer
259-1	7	#6 solder lug

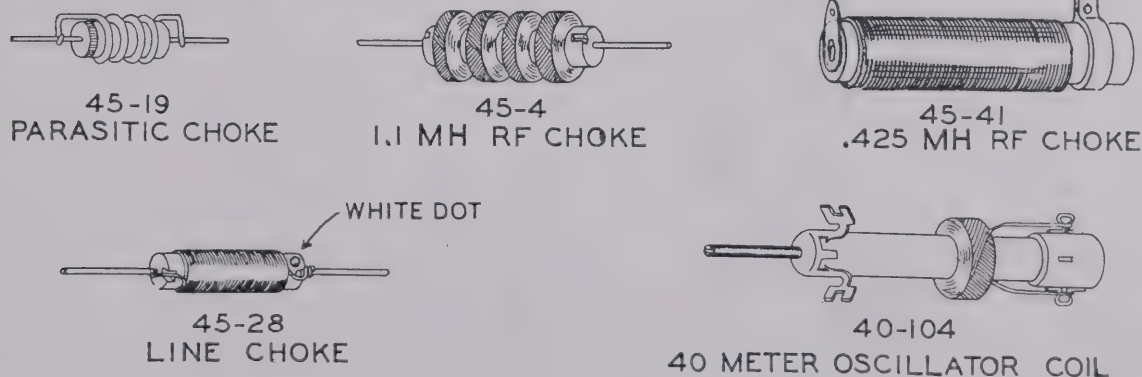
RESISTORS

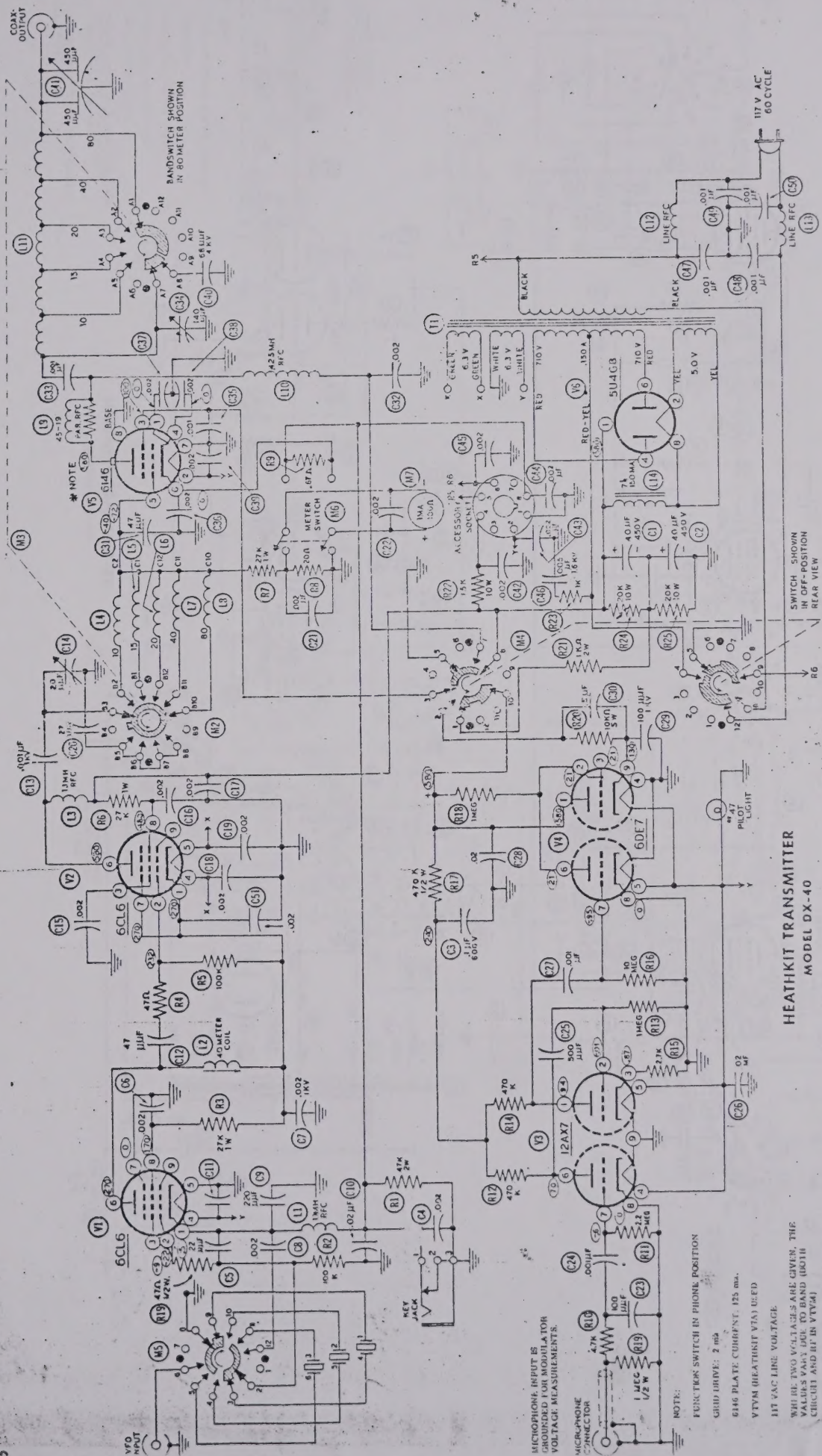


CAPACITORS



CHOKES





HEATHKIT TRANSMITTER
MODEL DX-40

MICROPHONE INPUT IS
GROUNDED FOR MODULATOR
VOLTAGE MEASUREMENTS.

MICROPHONE
CONNECTOR

NOTE:
FURTHER SWITCH IN PHONE POSITION

GRID DRIVE: 2 mb

6146 PLATE CURRENT: 125 ma.

VTVN (HEATHKIT VTN) USED

117 VAC LINE VOLTAGE

WHEN TWO VOLTAGES ARE GIVEN, THE
VALUES VARY DUE TO BAND (WITH
CIRCUIT AND HT IN VTVN)

• 6146 PLATE VOLTAGE MEASURED AT
PIN 1 OF 504GB.

